



**Washington State  
Department of Transportation**

**Memorandum**

April 12<sup>th</sup>, 2011

TO: Jeri Bernstein, Terminal Design Engineer  
WSF, TB-32

FROM: *J. J.* Tony Allen/Pete Palmerson  
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SUBJECT: XL-3493; SR-160 MP 7.48  
Vashon Ferry Terminal  
Timber Trestle Replacement Project  
Geotechnical Report

Attached is the preliminary geotechnical report for the proposed Vashon Ferry Terminal Timber Trestle Replacement Project. This report presents the results of the subsurface explorations and geotechnical analysis for preliminary design of the proposed project.

If you have questions or require further information, please contact Tony Allen at (360) 709-5450 or Pete Palmerson at (360) 709-5418.

TMA/pjp

Attachment: Preliminary Geotechnical Report

cc. Tom Bertucci TB-32

# PRELIMINARY GEOTECHNICAL REPORT

SR-160 MP 7.48

## Vashon Ferry Terminal Timber Trestle Replacement

XL-3493

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April 12<sup>th</sup>, 2011



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## **1. Project Location and Description**

This report presents the results of our geotechnical investigation and analyses for the Vashon Ferry Terminal Timber Trestle Replacement Project at the Vashon Island Ferry Terminal. The existing trestle is an approximately 800 foot long, 67 foot wide timber structure originally constructed in 1957. Preliminary geotechnical recommendations are given in this report to bring the trestle replacement to 30% design. It is our understanding that Washington State Ferries needs to have the type and number of foundation elements selected early in the design process in order to meet permit requirements. The project is located at the northern tip of Vashon Island in King County, Washington. A vicinity map illustrating the project location is presented in Figure 1 in Appendix A. When the PS&E is completed for this project, our office will provide a *Summary of Geotechnical Conditions* for inclusion in the Special Provisions.

The analyses, conclusions, and recommendations in this report are based upon four borings drilled for this project in addition to historical boring information near the project site. Information includes boring logs, historical borings near the project limits, historic pile driving records, published geologic information for the site and vicinity, a site reconnaissance and our experience with similar geologic materials. The data reviewed and exploratory borings are assumed to be representative of the subsurface conditions throughout the project area. If during construction, subsurface conditions differ from those described, we should be advised immediately so that we may re-evaluate our recommendations and provide assistance.

## **2. Geologic Setting**

### **2.1. Regional Geology**

This project is located in the central portion of the Puget Lowlands of western Washington. The Puget Lowland physiographic province consists of a broad, low-lying region situated between the Cascade Range to the east and the Olympic Mountains and Willapa Hills to the west. To the north, the San Juan Islands form the division between the Puget Lowland and the Strait of Georgia in British Columbia.

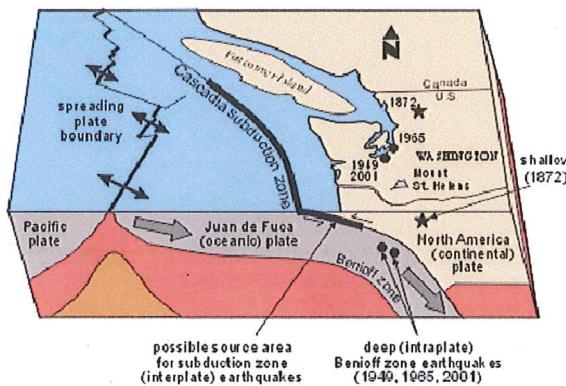
Starting in the early Pleistocene, the Puget Lowland was subject to four periods of extensive glaciation. The Puget Lowland owes its present-day geomorphic features to the last continental glacier that covered the region, the Vashon Stade of the Fraser Glaciation. Named the Cordilleran ice sheet, it consisted of two parts: one called the Puget Lobe, and the other named the Juan de Fuca Lobe. The ice sheet advanced from British Columbia 18,000 years ago to just south of Olympia; the entire Puget Lowland was covered by glacial ice. Streams and rivers draining the Cascades were dammed by the Cordilleran ice sheet. The waters were diverted south along the flanks of the Cascades, then around the terminus of the ice sheet south of Olympia, and finally out the Chehalis River Valley to the Pacific Ocean. By 14,000 years ago the ice had retreated to Seattle. Large areas south of Seattle were being covered by recessional outwash sands and gravels that are part of the Vashon Stade. At about the same time, thinning ice allowed marine waters to return to the Puget Lowland, and seawater lifted the ice and caused it to break up into berg ice over the entire region. Approximately 10,000 years ago, after a short-lived readvance in the northern Puget Lowland, the Cordilleran ice sheet disappeared, bringing the Ice Age to a close in this region.

## **2.2. Site Geology**

According to the geologic maps reviewed, the Vashon Ferry Terminal site is underlain by Quaternary age deposits of Vashon Advance Outwash and surrounded (on land) by Vashon Till. These deposits are glacially overridden and consist of boulders, cobbles, gravels, sand, silt and clay. The beach deposits at the site consist of poorly graded, unconsolidated clean sands, gravels and cobbles. The materials encountered during the subsurface investigation are consistent with the materials described on the maps. A Surficial Geology Map is shown in Figure 2 in Appendix A. In addition, a LiDAR (Light Detection and Ranging) map for the site was reviewed and is shown on Figure 3 in Appendix A. The LiDAR image shows surficial sloughing and gully erosion on the steep, water facing, glacial till cliffs surrounding this site, however none of the geomorphic or topographic features shown on the image appear to affect the site.

## **2.3. Regional Seismicity**

The seismicity of western Washington is predominantly influenced by the oblique subduction of the Juan de Fuca Plate under the North American Plate. The convergence between the plates is estimated to be about 4 centimeters per year. Within this active tectonic environment, three possible sources for seismic events in the Seattle area have been identified. The first two sources are intraplate and are related to the plate deformations and stress concentrations within the two plates as they are deformed by the subduction process. The first source is near surface within the continental crust of the uplifting North American Plate, and the second source is deeper within the subducting Juan de Fuca plate. The third source is off shore near the subduction line between the two plates and is related to movement along the subduction interface. This source has recently been referred to as the Cascadia Subduction Zone. These areas and locations of notable earthquakes are depicted in figure 2.2.1 below.



**Figure 2.2.1: Seismicity of Western Washington (Courtesy of the WSDNR)**

Shallow crustal seismicity within the North American plate, until recently, was thought to be limited in magnitude, less than 3 on the Richter scale, and unrelated to specific structures within the Puget Sound Lowland. Recent evidence suggests that some geologic structural control may be present and that these structures may be capable of producing shallow crustal seismic events with magnitudes greater than 6 on the Richter scale. One such structure is the inferred Seattle Fault. Evidence suggests that relatively recent activity has occurred along this fault, approximately 1,100 years ago.

Notable earthquakes within the region have generally been attributed to the intraplate seismicity within the Juan de Fuca plate. On April 13, 1949, a magnitude 7.0 earthquake occurred, on April 28, 1965, a magnitude 6.5 earthquake occurred, and on February 28, 2001, a magnitude 6.8 earthquake occurred. These three quakes are believed to be from this source. The quakes caused damage and liquefaction within the Seattle/Olympia area.

The Cascadia Subduction Zone has not experienced a known earthquake within the last 165 years of seismic record. However, evidence suggests that at various times within the last 3,500 years many coastal estuaries have experienced rapid subsidence as a result of seismic activity related to this zone. It is generally believed that this source is capable of producing seismic events as large as magnitude 9.

#### **2.4. Mapped Faults in the Area**

The United States Geological Survey (USGS) maintains information on faults and associated folds in the United States that are believed to be sources of earthquakes of magnitudes greater than six during the Quaternary Period (the past 1.6 million years). Figure 4 in Appendix A shows Quaternary Age regional fault locations. The features shown on Figure 4 are based on information contained in the USGS Quaternary Fault Database and a recent (2009) site specific ground motion analysis performed for the SR-520 Bridge Replacement and HOV Program. The most significant features based on proximity to the site are described as follows:

- *Puget Sound Fault Zone – less than 1 mile from site*

The Puget Sound Fault is a north-south trending zone of near vertical strike-slip fault strands which consists of segmented faults totaling approximately 34 miles in length. Slip rates are estimated between 0.3 and 0.8 millimeters per year. Seismic reflection data indicates a minimum rupture depth of 3.7 miles and modeling suggests a mean maximum magnitude of about 7 on the Richter scale.

- *Seattle Fault Zone – 2 miles north of site*

This is a 2.5 to 4 mile wide east-trending dipping thrust fault that extends from the Cascade Range foothills on the east across the Puget Lowland to Hood Canal. It forms the northern boundary of a belt of bedrock exposures that cross much of the Puget Lowland. Slip rates are estimated between 0.2 and 1.0 millimeters per year.

- *Tacoma Fault – 12 miles south of site*

Prominent geophysical anomalies extend west-northwest across the south-central Puget Lowland from the Tacoma region to Hood Canal. Local and regional experts are in agreement that the western, east-trending part of the geophysical anomalies is caused by the Tacoma fault, but no consensus exists for the eastern part. The existing information suggest, that the Tacoma fault is a backthrust to the south-dipping Seattle fault, and suggest that structural relief increases westward along the Tacoma fault. The Tacoma fault may have moved between 6 to 10 feet about 1,000 years ago.

- *Hood Canal Fault – 22 miles west of site*

The northerly striking Hood Canal fault zone is largely inferred from seismic-reflection data, gravity anomalies and some aeromagnetic data for the Puget Lowlands and the Olympic Mountains directly to the west. Interpretation of seismically imaged stratigraphic relationships implies considerable deformation of Tertiary bedrock and

complex depositional patterns in Quaternary deposits that have been affected by high-angle faulting. In seismic-reflection profiles, these high-angle faults appear to be principally normal faults associated with some reverse faults, and possible strike-slip offsets. Some interpretations of the tectonic relations suggest the most recent movement along faults of this zone is as young as late Holocene in age.

## **2.5. Site Seismicity**

Based on the AASHTO LRFD Bridge Design Specifications Section 3.10.2, a site specific procedure is necessary to determine the seismic hazard at the site. This is a requirement for structures within 6 miles of an active fault. However, due to the preliminary nature of this report, parameters based on the general procedure, as outlined in AASHTO Section 3.10.2.1 are provided in Section 7 of this report.

## **3. Site Conditions**

The project site is located at the northern end of Vashon Island in Puget Sound. The current structure is a timber trestle which is used to stage, load, and unload passengers and vehicles for the Vashon Island ferry; included on the trestle is a ferry terminal building and utilities. Outside of the replacement limits to the north and west, there exists a passenger only trestle, vehicle transfer spans, wingwalls and ferry dolphins.

The bulk of the existing timber trestle is supported on timber piles. A newer section of the existing trestle on the northwest end that supports the terminal building and mechanical equipment is supported on steel piling. Newer ancillary structures (dolphins and wingwalls, transfer spans) are supported on steel piling as well. The passenger only ferry gangway is supported on precast prestressed concrete piling while the ferry dock itself is a floating structure.

On shore, at the south end of the trestle, are residential and light commercial structures as well as the "Y" intersection of Vashon Highway SW and 103<sup>rd</sup> Avenue SW. The west side of Vashon Highway SW and both sides of 103<sup>rd</sup> Avenue SW are constructed in steep, deep cuts. Portions of the cuts on 103<sup>rd</sup> Avenue SW are supported by sheetpile retaining walls on the west and soldier pile and timber lagging walls on the east.

The intersection and surrounding area has numerous underground and overhead utilities. Two relatively large (30-inch plus) stormdrains, one from Vashon Highway SW and one from 103<sup>rd</sup> Avenue SW, daylight under the trestle abutment.

The existing timber piles and superstructure of the trestle are in poor condition with visible signs of fatigue and age.

A reinforced concrete retaining wall appears to have acted as the abutment support at one time, however it appears that subsequent work on the abutment area has removed some of the backfill and a large drainage pipe that went through the wall. The wall continues to support the structure but another timber pile with timber lagging soldier pile wall appears to have been installed behind the concrete wall.

A small boat launch constructed of timber and concrete lies on the east side of the existing trestle.

In regards to vegetation, the site exists primarily in and above the saltwater of Puget Sound, which limits any noticeable vegetation. To the south of the project, the deep cuts on the adjacent

roadways and surrounding areas have well established vegetation including mature trees, shrubs and vines, grasses as well as other vegetation. Within the project limits the site is exposed to the changing tides, with water depths of up to approximately 20 feet.

## 4. Field Exploration

### 4.1. Subsurface Exploration

The subsurface exploration consisted of advancing four borings drilled to depths of up to 101.5 feet below ground surface. In addition, four historical borings advanced between 1990 and 2007 were included for the design of this project. Plan locations of the borings are shown on the Site Plan, Figure 5 in Appendix A.

Boring elevations and coordinates were located by the Northwest Region survey crew. The explorations were continuously monitored, logs of subsurface conditions were maintained, and representative samples were collected. The soils collected were visually classified based on *modified* procedures as outlined in ASTM D-2488. Logs for the borings and a boring legend are contained in Appendix B. Logs for the historical borings are located in Appendix C. The edited logs of all the test borings should be made available to all prospective bidders and included in the contract documents.

### 4.2. Laboratory Testing

Laboratory testing was performed on selected samples from the field exploration program. Disturbed samples and undisturbed samples were recovered from the site. Disturbed samples are those that were obtained during the Standard Penetration Test (SPT). The disturbed samples were used for classification and index property testing. Undisturbed samples were taken with 3-inch Shelby tubes. A triaxial strength test was performed on one of the undisturbed samples.

All soil samples were visually examined and then grouped together based on particle size distribution, consistency, and color. Once groups of samples were established that had similar characteristics, a minimum of one sample per group was tested. The testing consisted of performing particle size analyses, determining the liquid limit if applicable, and determining the plastic limit and plasticity index if applicable. The tests were done in accordance with AASHTO T-88, T-89, and T-90 guidelines respectively. In addition, due to the extremely high moisture contents and the notation of organics observed in samples in the top 25 feet of H-01-11 a Loss on Ignition (LOI) test was performed on sample D-4. After the testing was complete, the samples were classified using the Unified Soil Classification System (USCS). The results for our laboratory testing are attached in Appendix D, and the results of historic laboratory testing are attached in Appendix E.

## 5. Site Soil Conditions

The soil deposits encountered in the test borings have been grouped into two soil units for geotechnical distinction. The soil units are grouped primarily on the basis of engineering properties, classification, and reflect depositional environments. The units are described individually below.

**Unit 1 – Unconsolidated Sands:** This unit was observed in borings each boring and consists of very loose to medium dense poorly to well graded sand with gravels and seashells. Typical USCS Soil Groups for this unit include: SM and SP. The deposit was observed starting at the surface/mudline to depths of 7 to 21 feet below the surface. Historic borings confirm the presence of similar materials within the project limits.

**Unit 2 – Advance Outwash:** This unit underlies Unit 1 in all of the borings. This unit consists of loose to very dense silt with occasional sand and gravel. The typical USCS Soil Group for this unit is ML. This unit was observed to boring completion in all of the borings. Historical borings confirm the presence of similar material within the project limits.

## 6. Surface Water and Groundwater

The project site lies on the northern end of Vashon Island near sea level while Vashon Heights, a topographic feature south of the site rises to approximately elevation 300 feet. Ground and surface water runs from the topographic relief of Vashon Heights to the shores of the Puget Sound. The previously noted cut slopes associated with the roadways indicate the presence of groundwater based on the vegetation and seeps at the face. The depth to groundwater on the shore will be dependent on tidal influence as well as rainfall, irrigation in the Heights, time of year, construction activities and other factors

## 7. Seismological Considerations

### 7.1. Design Earthquake Parameters

As noted in Section 2.5 of this report, a site specific procedure is necessary to determine the seismic hazard at the site. Seismic design parameters based on the general procedure, as outlined in AASHTO Section 3.10.2.1 are provided below. The parameters are based on a design seismic event with a seven percent probability of being exceeded in 75 years. A list of the design earthquake parameters can be found below in Table 7.1

Design response spectra presented in the AASHTO guide specification are considered appropriate for seismic design of the structures on this project. A Type D soil profile response spectrum is recommended for seismic design of the project.

Site class based on soil conditions	Site Class = D
Mean Magnitude	M= 6.66
Peak Horizontal ground acceleration coefficient on Class B rock	PGA = 0.48
0.2-sec period spectral acceleration coefficient on Class B rock	S <sub>s</sub> = 1.05
1.0-sec period spectral acceleration coefficient on Class B rock	S <sub>1</sub> = 0.36
Site coefficient for the peak ground acceleration coefficient	F <sub>pga</sub> = 1.03
Site coefficient for 0.2-sec period spectral acceleration	F <sub>a</sub> = 1.09
Site coefficient for 1.0-sec period spectral acceleration	F <sub>v</sub> = 1.70
Effective peak ground acceleration coefficient (g)	A <sub>s</sub> = F <sub>pga</sub> (PGA) = 0.49
Design earthquake response spectral accel. coeff. at 0.2-sec period	S <sub>DS</sub> = F <sub>a</sub> S <sub>s</sub> = 1.14
Design earthquake response spectral accel. coeff. at 1.0-sec period	S <sub>D1</sub> = F <sub>v</sub> S <sub>1</sub> = 0.61
Seismic Zone based on S <sub>D1</sub>	Seismic Zone = 4

Table 7.1 – Seismic Design Parameters

### 7.2. Liquefaction Potential

The liquefaction potential of saturated soils is evaluated mainly on soil gradation, density, and the depth of the deposit. The potential for liquefaction is highest for loose, fine to medium grained sands and silty sands. Increasing fines content (i.e. silt and clay) decreases the potential for liquefaction. Conversely, clean coarse grained granular soils are less susceptible to liquefaction due to their high permeability. The potential for liquefaction also decreases with increasing density and depth.

We have evaluated the potential for liquefaction of the project soils based on the SPT data, the acceleration coefficient and the grain size distribution of the soil. The analyses indicate the potential for liquefaction in the upper four feet of soil near the south end of the trestle, however the settlements and downdrag loads imposed by this soil layer are anticipated to be negligible.

### 7.3. Lateral Spreading

Based on our analysis, lateral spreading will occur during the design seismic event. Once the site specific seismic analysis has been performed and the foundation type, size and location has been determined, we recommend revisiting this analysis.

The final report should address the lateral spreading issue. Lateral loads from the spreading should be provided to the structural engineer to include in the analysis for the Extreme Event Limit State.

## **8. Geotechnical Recommendations**

### **8.1. Foundation Recommendations**

#### **8.1.1. Trestle Bent Support**

Due to the nature of the overwater construction, deep foundations will be necessary for the trestle bent support. Deep foundation options include both drilled shafts and driven piling. Typically, WSF projects have been constructed using relatively heavy wall steel piling. However based on environmental concerns, we understand that WSF wishes to consider precast, prestressed concrete piling as an option. Stingers, jetting and/or preboring may be required to advance piles to required tip elevations. These methods may create environmental concerns.

Since the support locations for the proposed new trestle have not been determined, pile parameters are based on the boring locations. Borings H-01-11, H-02-11 and H-03-11 have similar soil conditions and have been grouped accordingly. Boring H-04-11 soil conditions are somewhat different and have slightly different parameters.

#### **8.1.2. Axial Pile Resistance**

For preliminary design, we are providing recommendations for 18 inch concrete piles, 24 inch concrete piles and 30 inch open toe steel piles. Enclosed in Appendix F are nominal axial resistances for the Strength, Service and Extreme Event Limit States for each of the aforementioned pile types. When determining resistances between H-03-11 and H-04-11, linearly interpolate between the two borings.

Center-to-center pile spacing should not be less than the greater of 30 inches or 2.5 pile diameters or widths.

Resistance factors shown in Table 8.2.1 should be used to evaluate the various limit states.

Limit State	Resistance Factor $\phi$		
	Bearing (WSDOT Driving Formula)	Bearing (PDA/CAPWAP)	Uplift
Strength	0.55	0.65	0.35
Service	1.00	1.00	1.00
Extreme	1.00	1.00	1.00

**Table 8.1.2.1. Driven Pile Resistance Factors**

#### **8.1.3. Pile Group Settlement**

Based on the preliminary loads provided and a minimum pile embedment of 20 feet below the mudline, we estimate the settlement of the driven piles to be approximately 1-inch or less for the Service Limit State with the bulk of the settlement occurring during construction. Post construction settlement should be negligible.

#### **8.1.4. Lateral Load Parameters**

In order to perform a lateral analysis, L-pile input parameters are provided in Table 1 in Appendix F. For the P-y method of analysis, P-multipliers should be used to account for group effects. P-multiplier values can be found in AASHTO 2010 Section 10.7.2.4.

#### **8.1.5. Abutment Support**

From a geotechnical standpoint, the abutment can be supported on a spread footing or pile foundation.

A spread footing was analyzed for the abutment at the south end of the project near boring H-01-11; spread footing nominal bearing resistances are provided in Plot 7 in Appendix F for the Strength, Service and Extreme Event Limit State.

We recommend the bottom of the footing be placed a minimum of 7 feet below the existing (roadway) grade. Depending on the final abutment configuration, a scour analysis may be necessary. If this is the case, the results of the scour analysis should be provided to this office so we may incorporate them into our recommendations.

Service Limit State resistances are based on 1-inch or less of settlement. We anticipate that the bulk of the abutment settlement will occur in construction. Post construction settlement should be negligible. Resistance factors shown in Table 8.1.5.1 should be used to evaluate the various limit states.

Limit State	Resistance Factor ( $\phi$ )		
	Bearing ( $\phi_{bc}$ )	Shear Resistance to Sliding ( $\phi_v$ )	Passive Pressure Resistance to Sliding ( $\phi_{ep}$ )
Strength	0.45	0.80	0.50
Service	1.0	N/A	N/A
Extreme Event	1.0	1.0	1.0

**Table 8.1.5.1 Spread Footing Resistance Factors**

#### **8.2. Abutment Wall(s)**

We recommend a concrete cantilever or sheet pile wall to retain abutment soils. We recommend the following soil properties in Table 8.2.1 be used to estimate the earth pressures.

Parameter	Value
Unit Weight ( $\gamma$ )	130 pcf
Soil Friction ( $\phi_f$ )	36°
Active Earth Pressure ( $K_a$ )	0.23
Passive Earth Pressure ( $K_p$ )	3.5
Seismic Earth Pressure ( $K_{ae}$ )	0.41
Coefficient of Sliding ( $\tan \delta$ )	0.7

**Table 8.2.1 Abutment Wall Design Parameters.**

### **8.3. Approach Slabs**

According to the WSDOT Bridge Design Manual (BDM), all new structures require approach slabs to mitigate differential settlement adjacent to the end piers unless their use is determined to be inappropriate. There are no geotechnical reasons to eliminate approach slabs.

## **9. Construction Considerations**

When the type, size and location of foundation elements have been determined, we recommend performing a wave equation analysis to determine pile drivability and to compare estimate driving stresses to allowable stresses in the piles.

Spread footing construction near the abutment will almost certainly encounter wet conditions. It is likely that dewatering will be necessary.

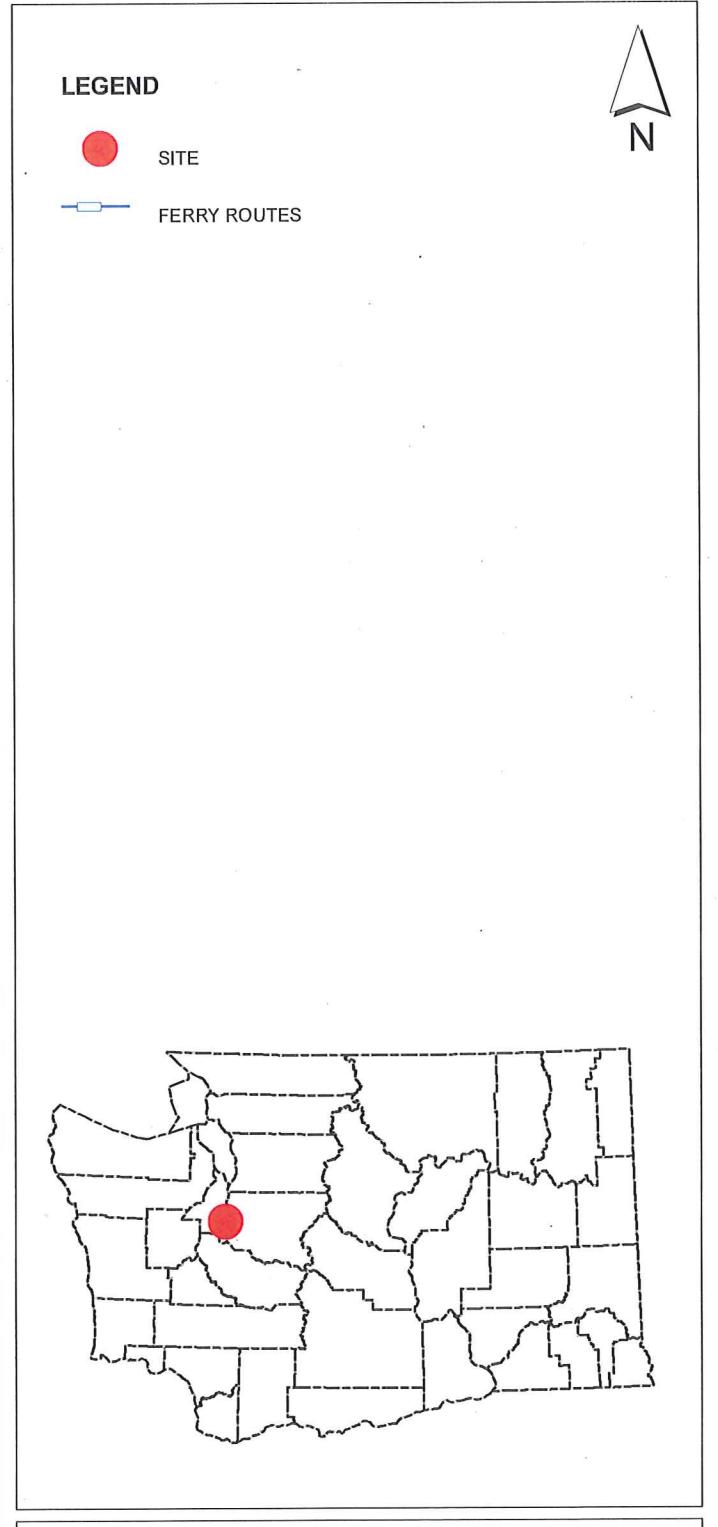
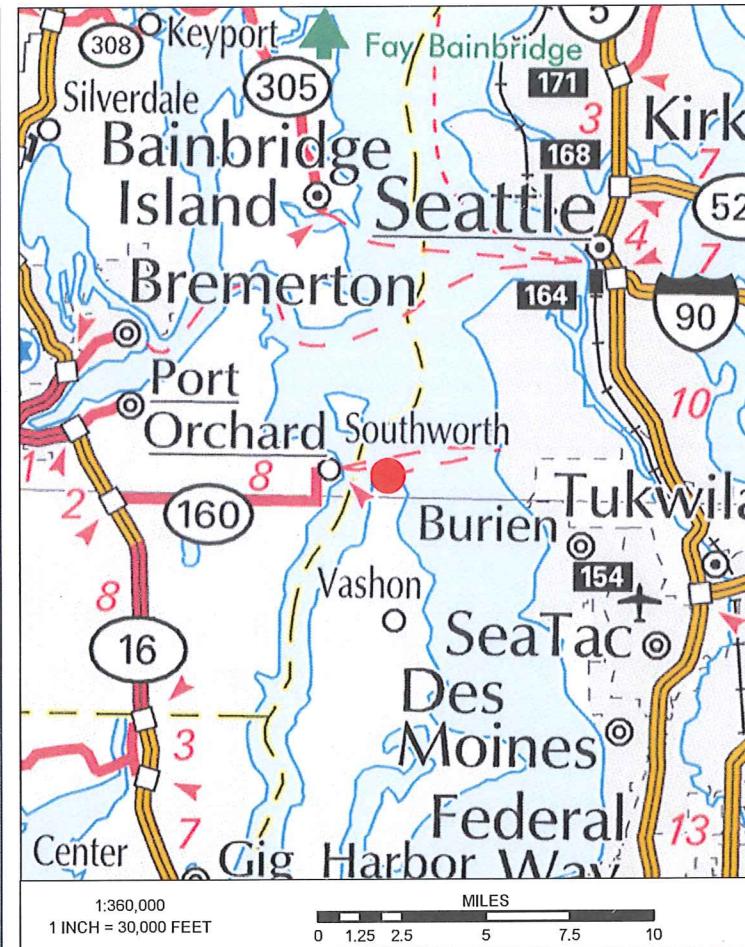
Cutting shoes, stingers and/or preboring may be required to advance piles to required tip elevations. We will provide recommendations for these items once the trestle support is well defined.

## **10. Closure**

If you have any questions or require further information, please contact Pete Palmerson at 360.709.5418 or Tony Allen at 360.709.5450.

## **Appendix A – Figures**

- Figure 1 – Vicinity Map
- Figure 2 – Surficial Geology Map
- Figure 3 – LiDAR Map
- Figure 4 – Quarternary Regional Fault Locations
- Figure 5 – Site Plan
- Figure 6 – Subsurface Profile



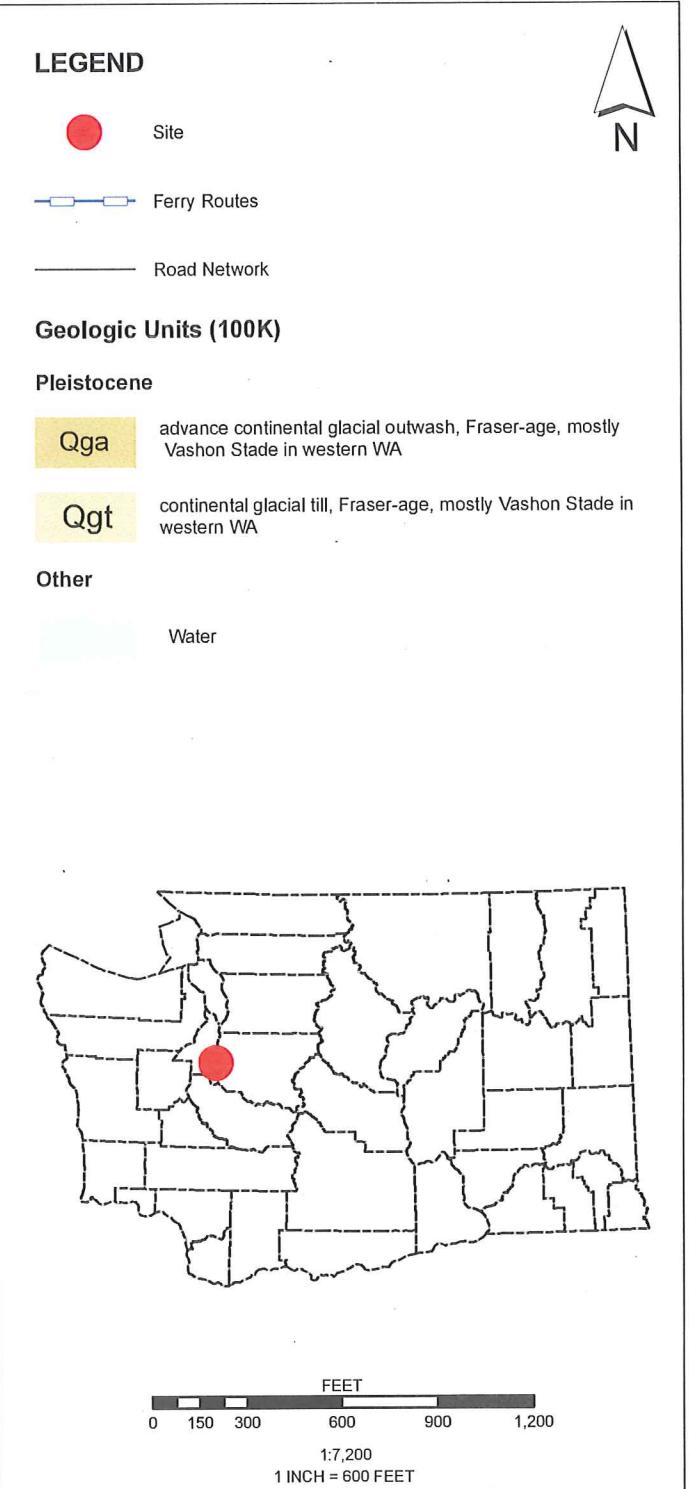
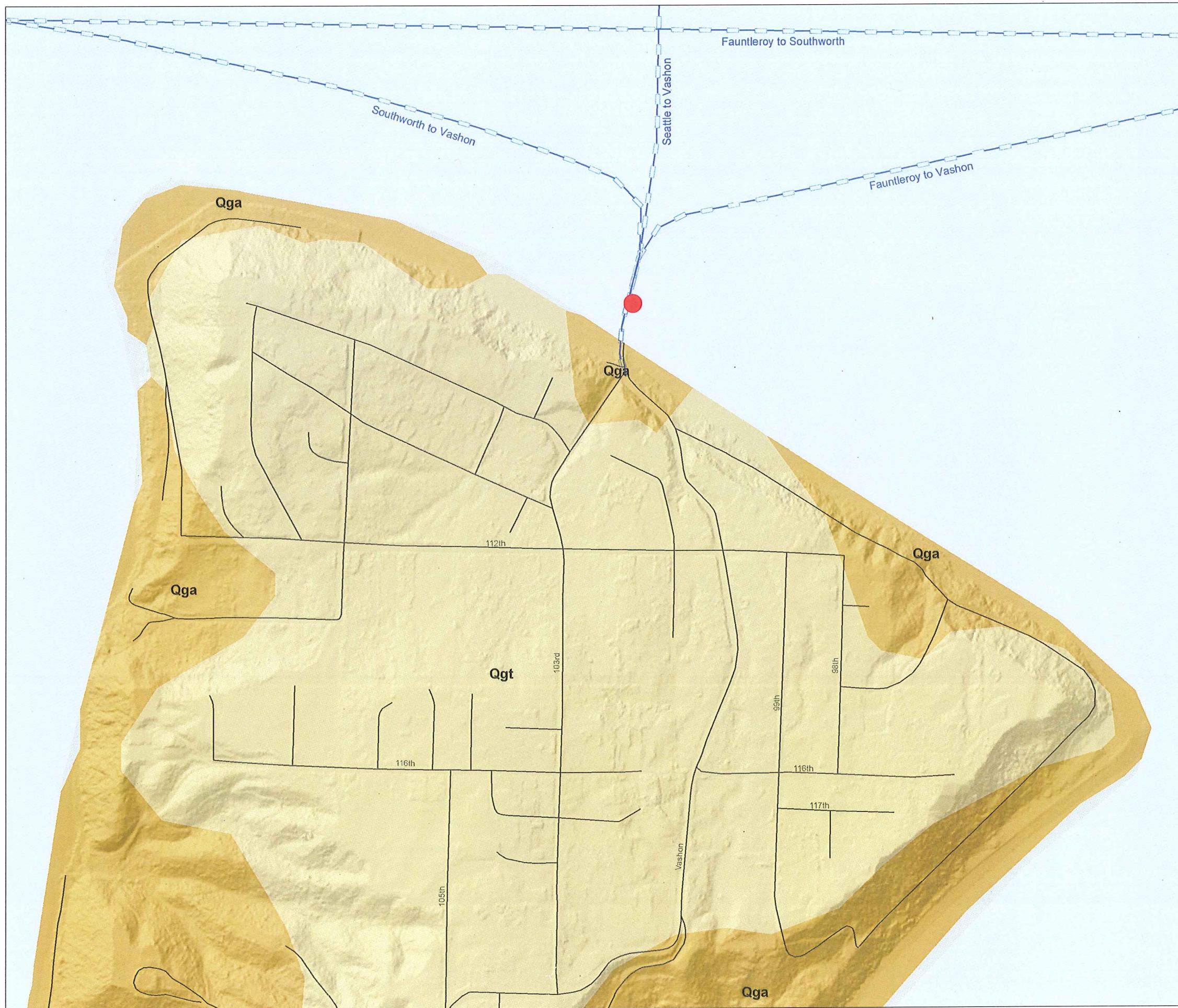
**FIGURE 1: VICINITY MAP**

Vashon Ferry Terminal  
Timber Trestle Replacement

 Washington State Department of Transportation  
**GEOTECHNICAL DIVISION**

PREPARED BY Tracy Tropel

DATE January 27, 2011



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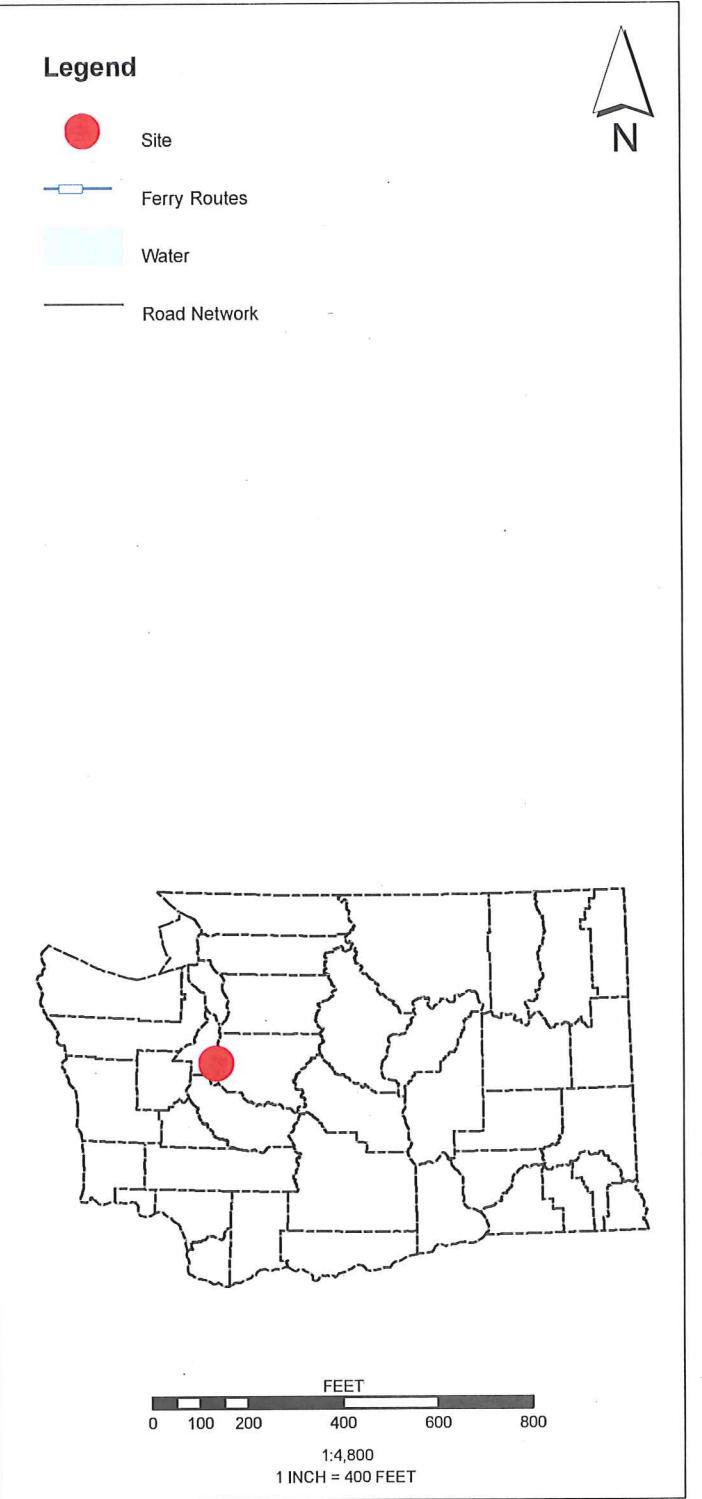
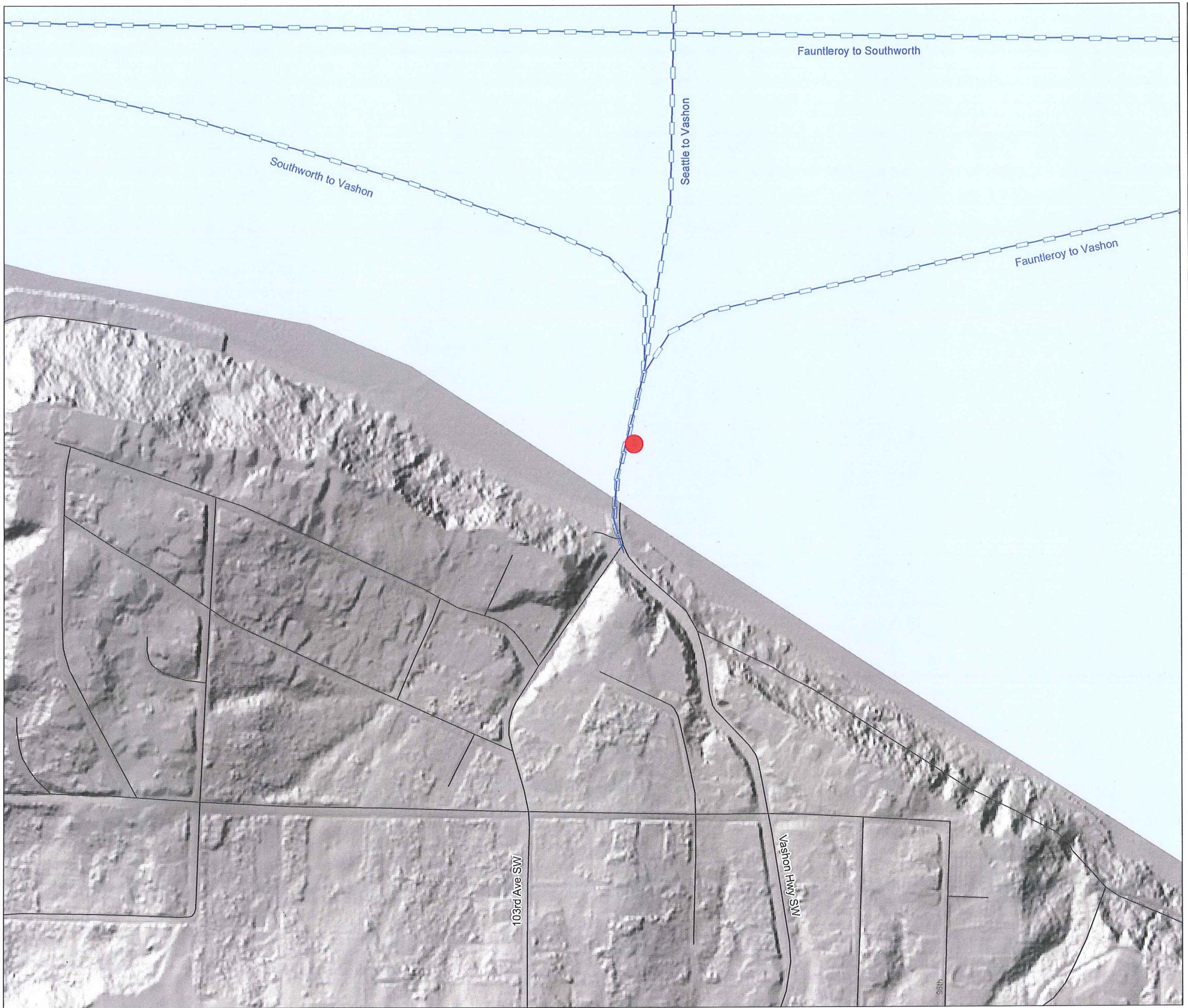
**FIGURE 2: SURFICIAL GEOLOGY MAP**

Vashon Ferry Terminal  
Timber Trestle Replacement

Washington State Department of Transportation  
**GEOTECHNICAL DIVISION**

PREPARED BY Tracy Trople

DATE February 23, 2011



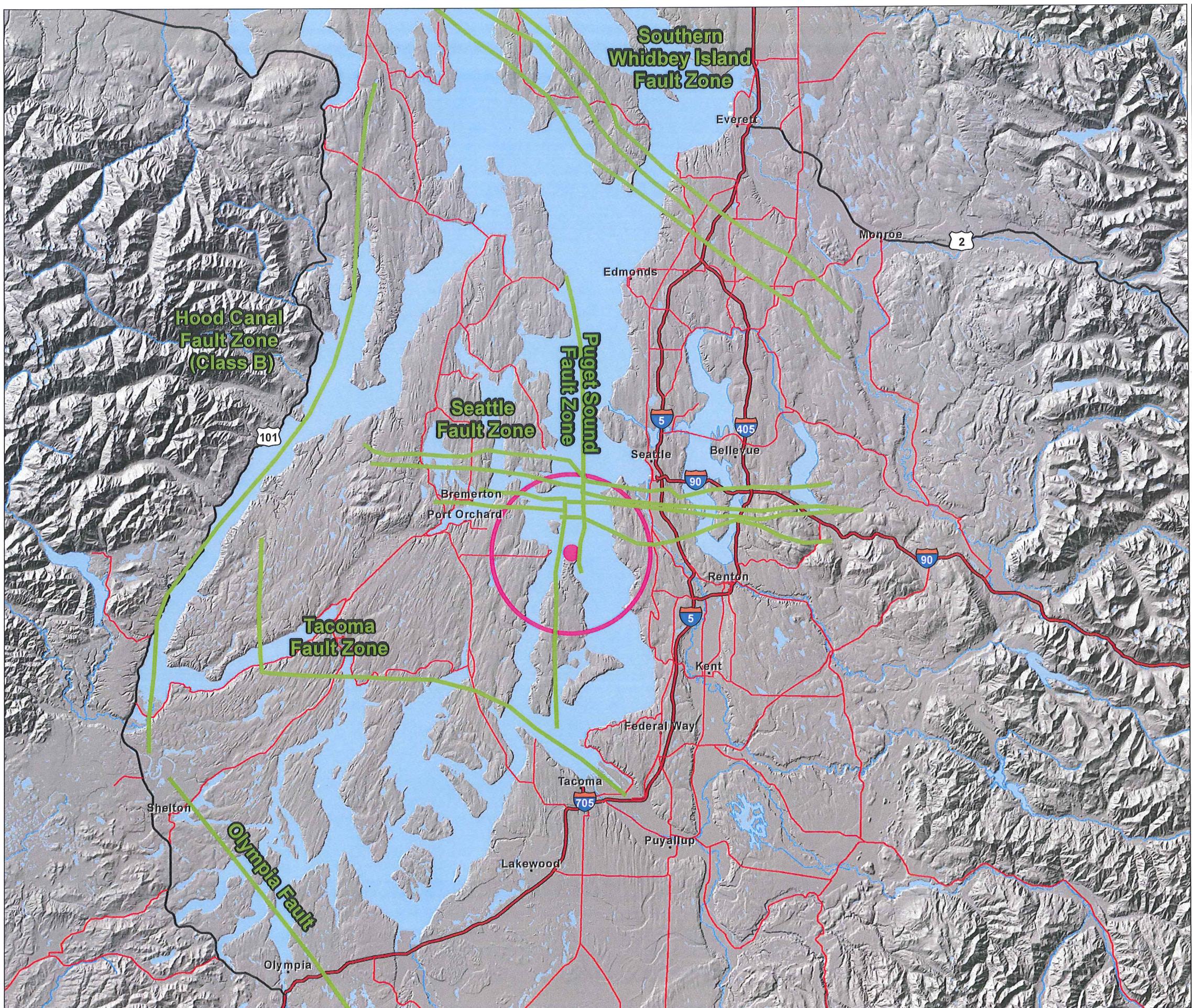
**FIGURE 3: LiDAR MAP**

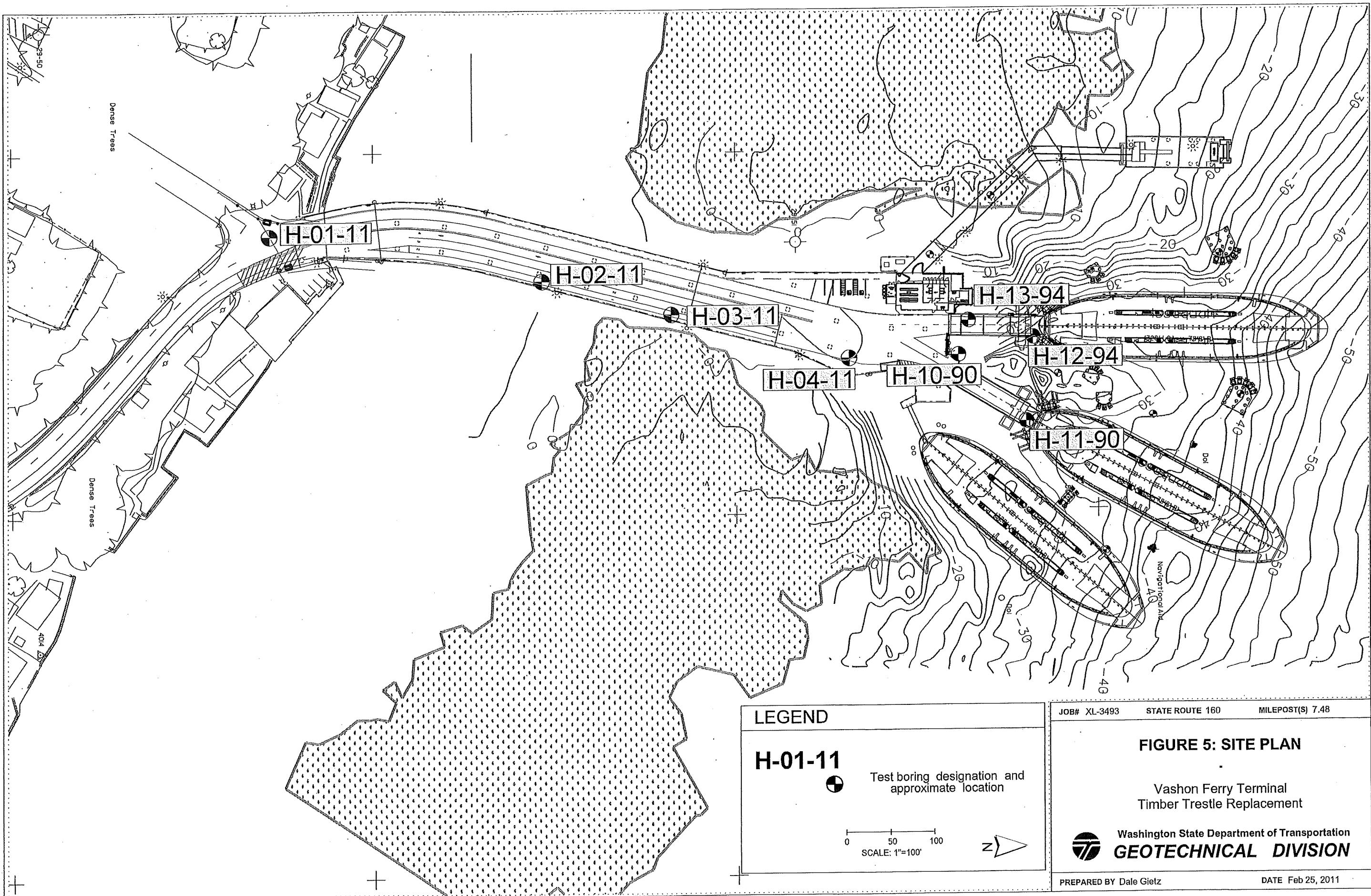
Vashon Ferry Terminal  
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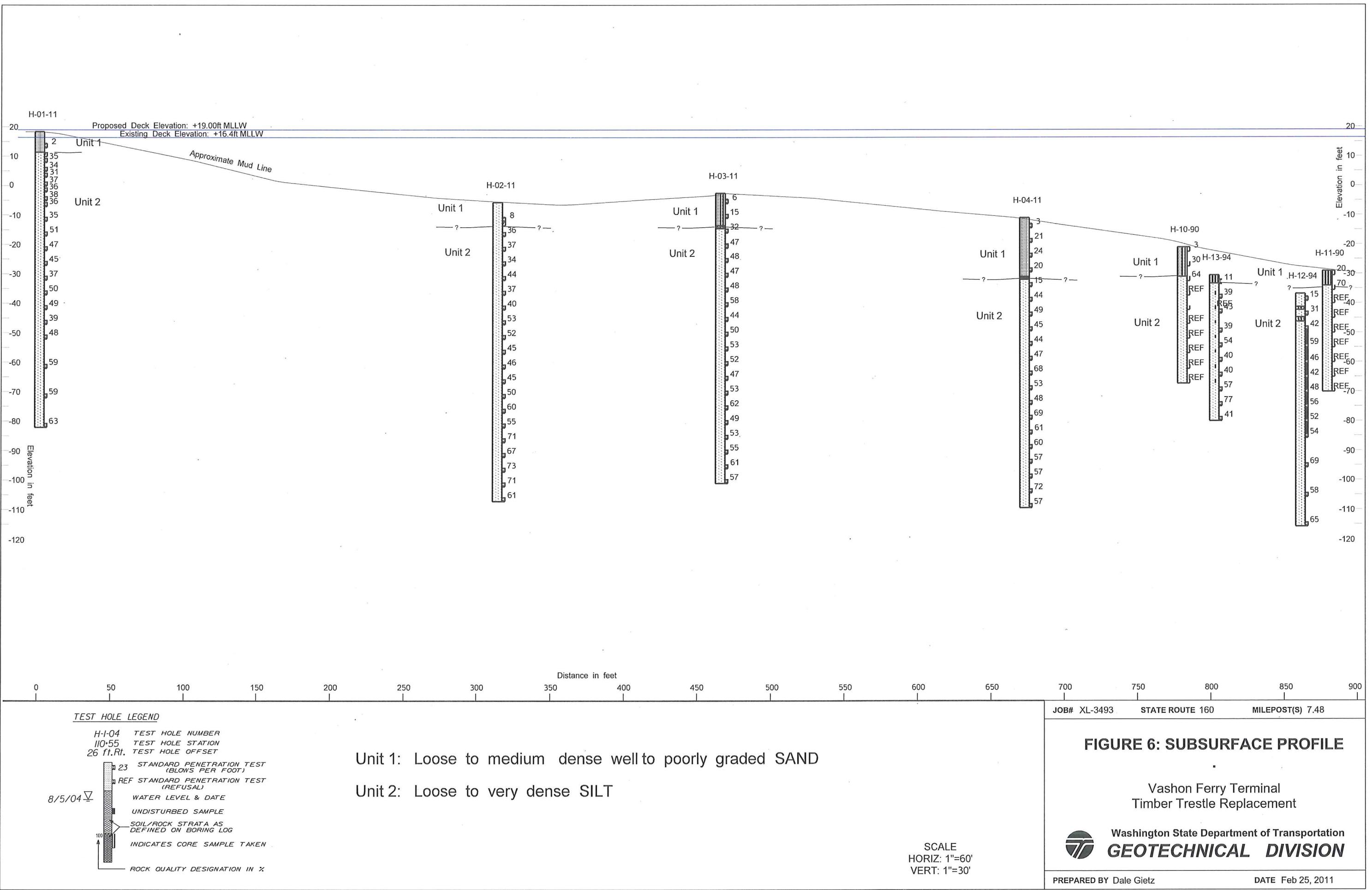
Washington State Department of Transportation  
**GEOTECHNICAL DIVISION**

PREPARED BY Tracy Trople

DATE February 23, 2011







## **Appendix B –Boring Logs**

- H-01-11
- H-02-11
- H-03-11
- H-04-11



## Test Boring Legend

Page 1 of 2

Sampler Symbols	
	Standard Penetration Test
	Oversized Penetration Test (Dames & Moore, California)
	Shelby Tube
	Piston Sample
	Washington Undisturbed
	Vane Shear Test
	Core
	Becker Hammer
	Bag Sample

Well Symbols	
	Cement Surface Seal
	Piezometer Pipe in Granular Bentonite Seal
	Piezometer Pipe in Sand
	Well Screen in Sand
	Granular Bentonite Bottom Seal
	Inclinometer Casing in Concrete Bentonite Grout

Laboratory Testing Codes	
UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
UC	Unconfined Compression Test
DS	Direct Shear Test
CN	Consolidation Test
GS	Grain Size Distribution
MC	Moisture Content
SG	Specific Gravity
OR	Organic Content
DN	Density
AL	Atterberg Limits
PT	Point Load Compressive Test
SL	Slate Test
DG	Degradation
LA	LA Abrasion
HT	Hydrometer Test

Soil Density Modifiers			
Gravel, Sand & Non-plastic Silt	Elastic Silts and Clay	SPT Blows/ft	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-24	Medium Dense	5-8	Medium Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
(REF)	Refusal	31-60	Hard
		>60	Very Hard

Angularity of Gravel & Cobbles	
Angular	Coarse particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Coarse grained particles are similar to angular but have rounded edges.
Subrounded	Coarse grained particles have nearly plane sides but have well rounded corners and edges.
Rounded	Coarse grained particles have smoothly curved sides and no edges.

Soil Moisture Modifiers	
Dry	Absence of moisture; dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water

Soil Structure	
Stratified	Alternating layers of varying material or color at least 6mm thick; note thickness and inclination.
Laminated	Alternating layers of varying material or color less than 6mm thick; note thickness and inclination.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into smaller angular lumps which resist further breakdown.
Disrupted	Soil structure is broken and mixed. Infers that material has moved substantially - landslide debris.
Homogeneous	Same color and appearance throughout.

HCl Reaction	
No HCl Reaction	No visible reaction.
Weak HCl Reaction	Some reaction with bubbles forming slowly.
Strong HCl Reaction	Violent reaction with bubbles forming immediately.

Degree of Vesicularity of Pyroclastic Rocks	
Slightly Vesicular	5 to 10 percent of total
Moderately Vesicular	10 to 25 percent of total
Highly Vesicular	25 to 50 percent of total
Scoriaceous	Greater than 50 percent of total



# Test Boring Legend

Page 2 of 2

Grain Size		
Fine Grained	< 1mm	Few crystal boundaries/grains are distinguishable in the field or with hand lens.
Medium Grained	1mm to 5mm	Most crystal boundaries/grains are distinguishable with the aid of a hand lens.
Coarse Grained	> 5mm	Most crystal boundaries/grains are distinguishable with the naked eye.

Weathered State		
Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discoloration in major discontinuity surfaces.	<b>I</b>
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than its fresh condition.	<b>II</b>
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as core stones.	<b>III</b>
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as discontinuous framework or as core stone.	<b>IV</b>
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	<b>V</b>
Residual Soil	All rock material is converted to soil. The mass structure and material fabric is destroyed. There is a large change in volume, but the soil has not been significantly transported.	<b>VI</b>

Relative Rock Strength			
Grade	Description	Field Identification	Uniaxial Compressive Strength approx
R1	Very Weak	Specimen crumbles under sharp blow from point of geological hammer, and can be cut with a pocket knife.	150-3500 psi
R2	Moderately Weak	Shallow cuts or scrapes can be made in a specimen with a pocket knife. Geological hammer point indents deeply with firm blow.	3500-7500 psi
R3	Moderately Strong	Specimen cannot be scraped or cut with a pocket knife, shallow indentation can be made under firm blows from a hammer.	7500-15000 psi
R4	Strong	Specimen breaks with one firm blow from the hammer end of a geological hammer.	15000-30000 psi
R5	Very Strong	Specimen requires many blows of a geological hammer to break intact sample.	Greater than 30000 psi

Discontinuities		
Spacing		Condition
Very Widely	Greater than 3 m	Excellent Very rough surfaces, no separation, hard discontinuity wall
Widely	1 m to 3 m	Good Slightly rough surfaces, separation less than 1 mm, hard discontinuity wall.
Moderately	0.3 m to 1 m	
Closely	50 mm to 300 mm	Fair Slightly rough surfaces, separation greater than 1 mm, soft discontinuity wall.
Very Closely	Less than 50 mm	
RQD (%)		Poor Slickensided surfaces, or soft gouge less than 5 mm thick, or open discontinuities 1 to 5 mm.
100(length of core in pieces > 100mm) Length of core run		Very Poor Soft gouge greater than 5 mm thick, or open discontinuities greater than 5 mm.

Fracture Frequency (FF) is the average number of fractures per 300 mm of core.  
Does not include mechanical breaks caused by drilling or handling.



Washington State  
Department of Transportation

## LOG OF TEST BORING

Job No. XL-3493 SR 163

Elevation 18.4 ft

Start Card S 42659

HOLE No. H-01-11

Sheet 1 of 5

Driller Shepherd, Robert Lic# 2710

Project SR 160 Vashon Trestle Preservation

Inspector Hilts, Brian #2249

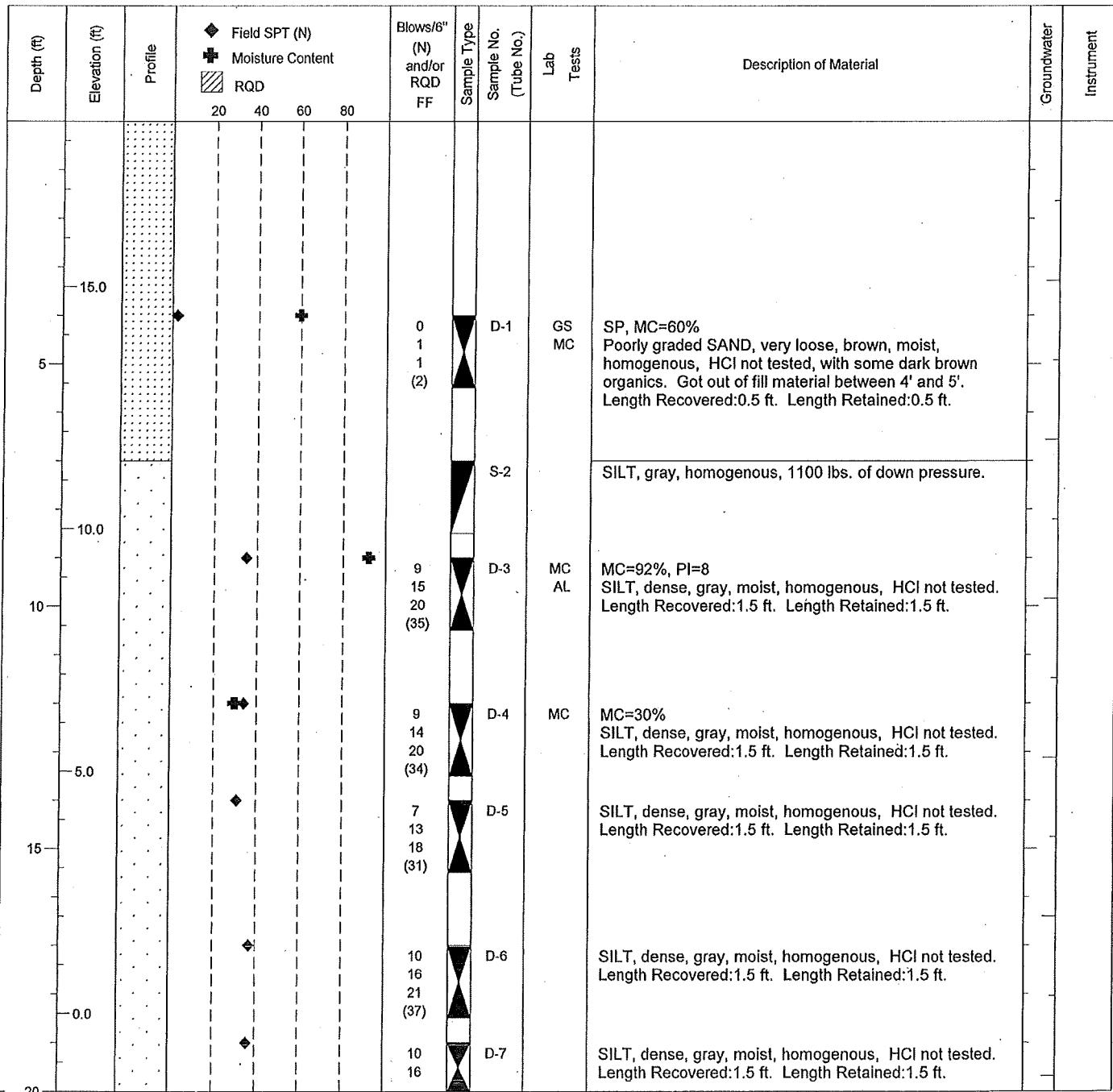
Site Address Vic. of 103rd. Ave. SW and Vashon Hwy. SW

Start January 18, 2011 Completion January 19, 2011 Well ID#  Equipment CME 55 truck (9C1-3) - AH

Station 0. Offset 0. Hole Dia 6 (inches) Method Wet Rotary

Northing 189760.55 Easting 1237377.56 Collected by Region Survey Crew Datum State Plane North

County King Subsection NE1/4 of SE1/4 Section 6 Range 3 EWM Township 23N





Washington State  
Department of Transportation

# LOG OF TEST BORING

Start Card S 42659

Job No. XL-3493

SR 163

Elevation 18.4 ft

HOLE No. H-01-11

Sheet 2 of 5

Driller Shepherd, Robert

Lic# 2710

Project SR 160 Vashon Trestle Preservation

Depth (ft)	Elevation (ft)	Profile	Field SPT (N)				Blows/6"	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			20	40	60	80							
-5	-5		◆				20 (36)	◆			MC=98%, PI=7 SILT, dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
25	25		◆				9 16 22 (38)	◆	D-8	MC AL	SILT, dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
30	30		◆				8 15 21 (36)	◆	D-9				
35	35		◆				9 15 20 (35)	◆	D-10		SILT, dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
40	40		◆				10 19 32 (51)	◆	D-11		SILT, very dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
45	45		◆				11 19 28 (47)	◆	D-12		SILT, dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
			◆				10 19	◆	D-13	MC AL	MC=30%, PI=13 SILT, dense, gray, moist, homogenous, HCl not tested.		



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S 42659

Job No. XL-3493

SR 163

Elevation 18.4 ft

HOLE No. H-01-11

Sheet 3 of 5

Driller Shepherd, Robert

Lic# 2710

Project SR 160 Vashon Trestle Preservation

Depth (ft)	Elevation (ft)	Profile	Soil Properties				Blows/6"	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			Field SPT (N)	Moisture Content	RQD	FF							
-30							26 (45)	◆			Length Recovered:1.5 ft. Length Retained:1.5 ft.		
50			◆				11 16 21 (37)	◆	D-14		SILT, dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
55			◆				10 19 31 (50)	◆	D-15		SILT, very dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
60			◆				10 21 28 (49)	◆	D-16		SILT, dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
65			◆				11 17 22 (39)	◆	D-17		SILT, dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
70			◆				12 20	◆	D-18		SILT, dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S 42659

Job No XL-3493

SR 163

Elevation 18.4 ft

HOLE No. H-01-11

Sheet 4 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert Lic# 2710

Depth (ft)	Elevation (ft)	Profile	Field SPT (N)				Blows/6"	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			◆	◆	◆	◆							
-55							28 (48)	◆					
75													
-60													
80			◆	◆			13 23 36 (59)	◆	D-19	MC AL	MC=26%, LL=NA, PL=NP SILT, very dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-65													
85													
-70													
90			◆				13 28 31 (59)	◆	D-20		SILT, very dense, gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-75													
95													



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S 42659

Job No XL-3493

SR 163

Elevation 18.4 ft

HOLE No. H-01-11

Sheet 5 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile	Soil Test Data				Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			Field SPT (N)	Moisture Content	RQD	Blows/6"						
-80												
100												
-85												
105												
-90												
110												
-95												
115												
-100												
120												



Washington State  
Department of Transportation

## LOG OF TEST BORING

Job No. XL-3493

SR 163

Elevation -5.7 ft

Project SR 160 Vashon Trestle Preservation

Site Address Vic of 103rd Ave. + Vashon Hwy. S.W.

Start Card S-42659

HOLE No. H-02-11

Sheet 1 of 5

Driller Shepherd, Robert Lic# 2710

Inspector Harvey, Thomas #2599

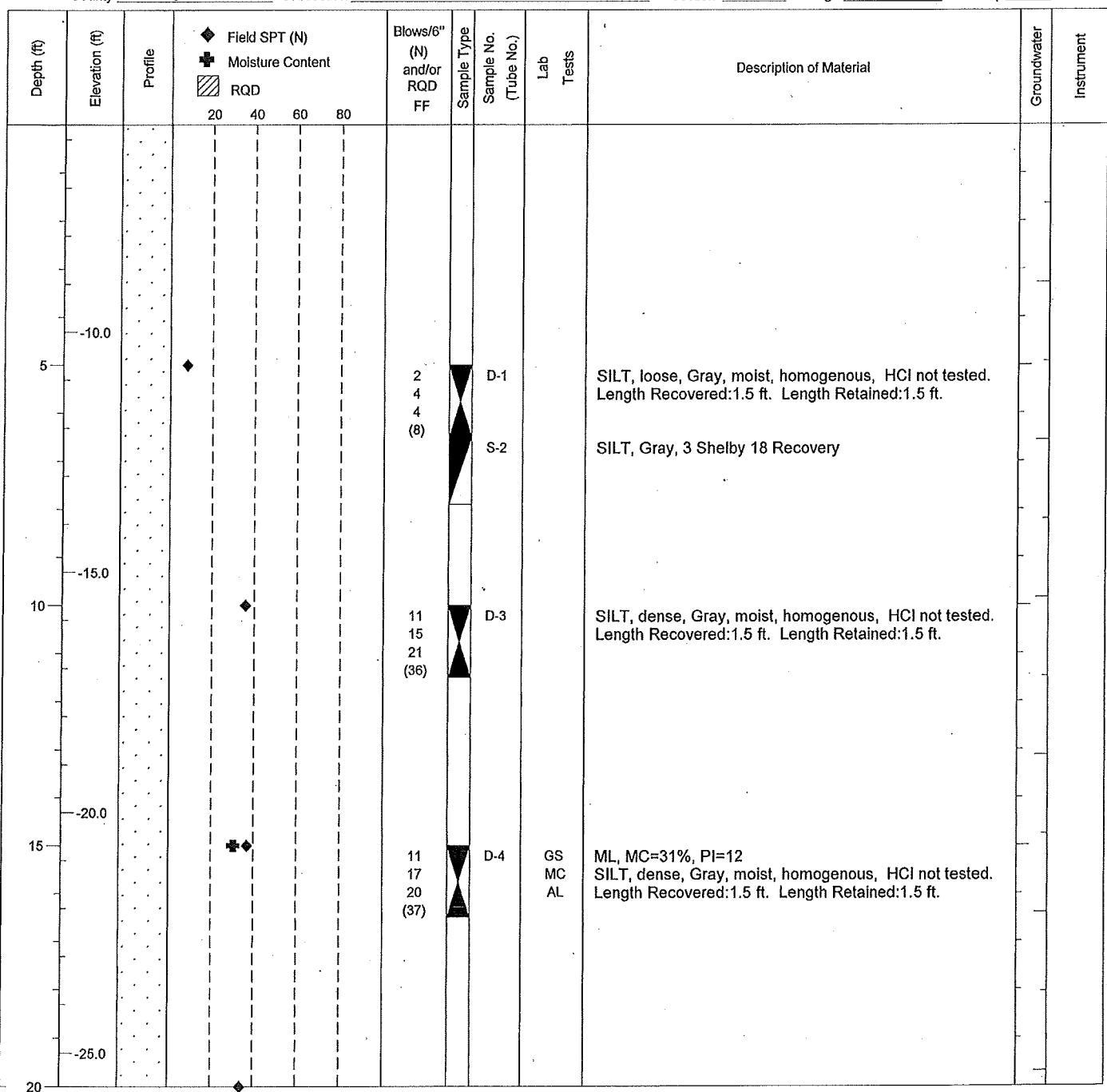
Start January 13, 2011 Completion January 14, 2011 Well ID#

Station \_\_\_\_\_ Offset \_\_\_\_\_ Hole Dia 6  
(inches)

Northing 190069.22 Easting 1237430.97 Collected by Region Survey Crew

Datum State Plane North

County 17-King Subsection NE1/4 of SE1/4 Section 6 Range 3EWM Township 23N





Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -5.7 ft

HOLE No. H-02-11

Sheet 2 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile					Description of Material	Groundwater	Instrument	
			◆ Field SPT (N)	✚ Moisture Content	▨ RQD	Blows/6"	Sample Type	Sample No. (Tube No.)	Lab Tests	
			20	40	60	80				
-30							12 14 20 (34)	D-5		SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.
25			◆				12 18 26 (44)	D-6		SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.
-35			◆				11 16 21 (37)	D-7		SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.
30			◆				12 16 24 (40)	D-8		SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.
-40			◆				16 23 30 (53)	D-9	MC AL	MC=33%, PI=9 SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.
40			✚		◆					
-45										
40										
-50										
45										



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

HOLE No. H-02-11

Sheet 3 of 5

Job No. XL-3493

SR 163

Elevation -5.7 ft

Project SR 160 Vashon Trestle Preservation.

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile	Description of Material				Groundwater	Instrument			
			◆ Field SPT (N)	+ Moisture Content	RQD	Blows/6"	Type	Sample No. (Tube No.)	Lab	Tests	
			◆			12 19 33 (52)	D-10			SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
-55	50		◆			14 18 27 (45)	D-11			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
-60	55		◆			13 17 29 (46)	D-12			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
-65	60		*	◆		13 18 27 (45)	D-13	MC AL		MC=33%, PI=7 SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
-70	65			◆		16 23 27 (50)	D-14			SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
-75											
70											



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No XL-3493

SR 163

Elevation -5.7 ft

HOLE No. H-02-11

Sheet 4 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert Lot# 2710

Depth (ft)	Elevation (ft)	Profile	◆ Field SPT (N) + Moisture Content ▨ RQD	Blows/6"	Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			◆ Field SPT (N) + Moisture Content ▨ RQD	20 40 60 80						
-80	75		◆			16 26 34 (60)	D-15	SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-85	80		◆			14 25 30 (55)	D-16	SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-90	85		◆			18 31 40 (71)	D-17	SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-95	90		◆			18 29 38 (67)	D-18	MC AL SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-100	95		◆			21 31 42 (73)	D-19	SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -5.7 ft

HOLE No. H-02-11

Sheet 5 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile	◆ Field SPT (N) + Moisture Content ▨ RQD	Blows/6" (N) and/or RQD FF	Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			20 40 60 80	17 29 42 (71)	D-20			SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-105	100		◆	19 27 34 (61)	D-21			SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-110	105							The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Division and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
-115	110							End of test hole boring at 101.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
-120	115							Bail/Recharge test: Hole Diameter: 6 Depth of boring during bail test: 101.5' Depth of casing during bail test: 95' Bailed bore hole water level to 10' Recharge after 30 minutes :10'		
-125	120							Deck elevation is 16.31 ft as provided by region survey crew. Mudline is located 22 ft below the deck of the ferry trestle. Mudline elevation is calculated at -5.69 ft.		



Washington State  
Department of Transportation

## LOG OF TEST BORING

Job No. XL-3493

SR 163

Elevation -2.6 ft

Start Card S-42659

HOLE No. H-03-11

Sheet 1 of 5

Driller Shepherd, Robert Lic# 2710

Inspector Harvey, Thomas #2599

Site Address Vic of 103rd Ave. + Vashon Hwy. S.W.

Start January 12, 2011 Completion January 13, 2011 Well ID#  Equipment CME-55 (9C1-3) - AH

Station

Offset

Hole Dia  
(inches) 6

Method Mud Rotary

Northing 190215.66

Easting 1237470.43

Collected by Region Survey Crew

Datum State Plane North

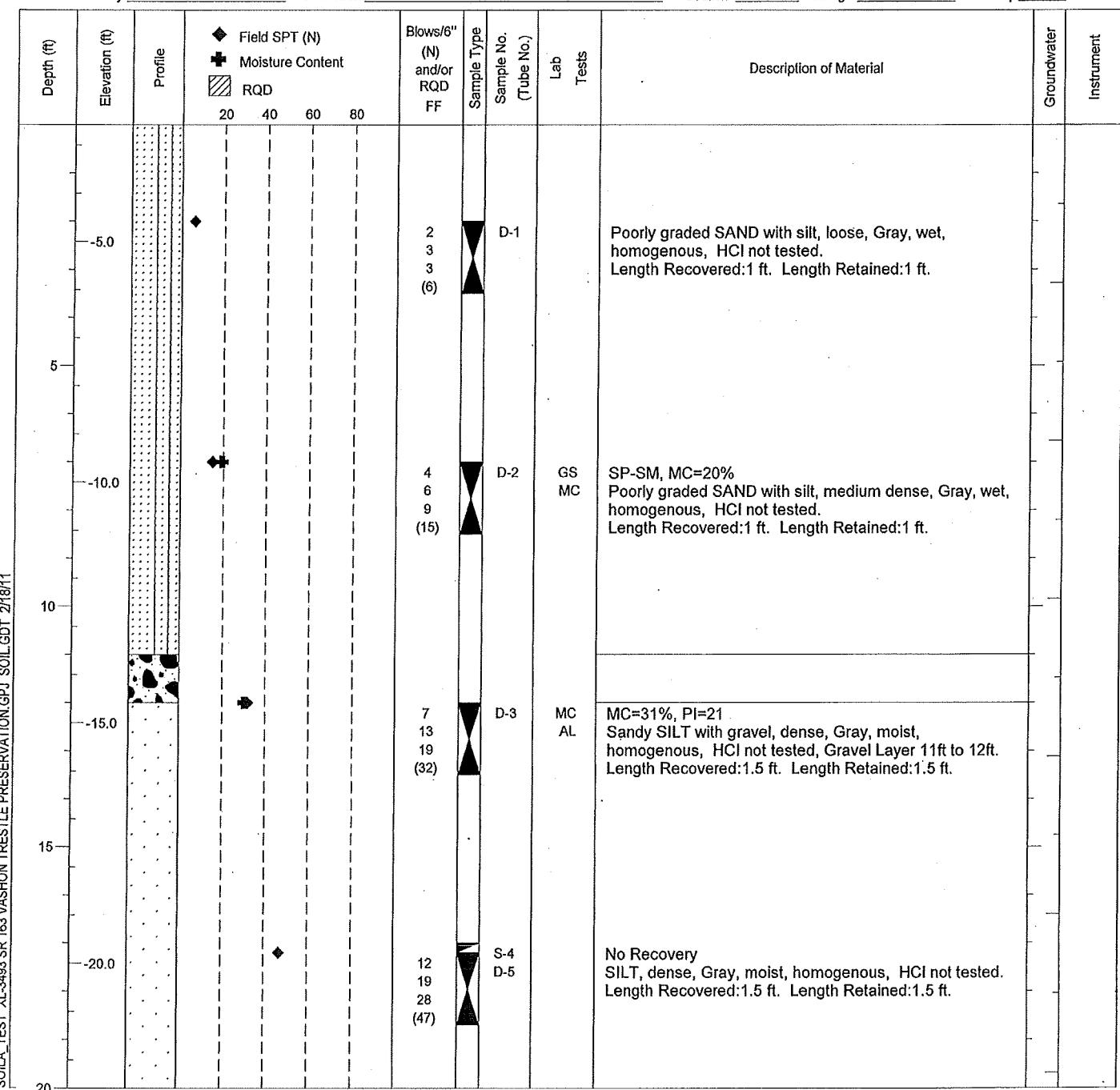
County 17-King

Subsection NE1/4 of SE1/4

Section 6

Range 3EWM

Township 23N





Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -2.6 ft

HOLE No. H-03-11

Sheet 2 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile					Description of Material			Groundwater	Instrument
			◆ Field SPT (N)	✚ Moisture Content	▨ RQD	Blows/6"	Sample Type	Sample No. (Tube No.)	Lab Tests		
20	40	60	80								
-25						14 20 28 (48)	D-6			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
25						17 21 26 (47)	D-7			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
30						16 22 26 (48)	D-8			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
35						17 26 32 (58)	D-9	MC AL		MC=27%, PI=7 SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
40						17 20 24 (44)	D-10			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	
45											



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -2.6 ft

HOLE No. H-03-11

Sheet 3 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile	◆ Field SPT (N) ✖ Moisture Content ▨ RQD	Blows/6" (N) and/or RQD FF	Sample Type (Tube No.)	Sample No. (Tube No.)	Lab	Tests	Description of Material	Groundwater	Instrument
-50	-50			18 24 26 (50)	D-11				SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-55	-55			16 24 29 (53)	D-12				SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-60	-60		✖	18 29 23 (52)	D-13		MC AL		MC=27%, LL=NA, PL=NP SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-65	-65			16 20 27 (47)	D-14				SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-70	-70			17 23 30 (53)	D-15				SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -2.6 ft

HOLE No. H-03-11

Sheet 4 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile	◆ Field SPT (N) ◆ Moisture Content ◆ RQD	Blows/6" (N) and/or RQD FF	Sample Type (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
-75	75	.	.	14 27 35 (62)	D-16	.	SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	.	.
-80	75	.	◆	16 24 25 (49)	D-17	.	SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	.	.
-85	80	.	◆	16 24 29 (53)	D-18	.	SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	.	.
-90	85	.	◆	17 27 28 (55)	D-19	.	SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	.	.
-95	90	.	◆	16 24 37 (61)	D-20	.	SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.	.	.
95	95	.	.	.	.	.	.	.	.



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -2.6 ft

HOLE No. H-03-11

Sheet 5 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation	Profile					Blows/6"	Sample Type	Sample No. (Tube No.)	Lab	Tests	Description of Material	Groundwater	Instrument
			◆ Field SPT (N)	✚ Moisture Content	▨ RQD	20 40 60 80								
-100							19 29 28 (57)	D-21				SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-105												The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Division and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
-110												End of test hole boring at 98.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
-115												Bail/Recharge test: Hole Diameter: 6' Depth of boring during bail test: 98.5' Depth of casing during bail test: 92' Bailed bore hole water level to 7' Recharge after 30 minutes :7'		
-120												Deck elevation is 16.42 ft as provided by region survey crew. Mudline is located 19 ft below the deck of the ferry trestle. Mudline elevation is calculated at -2.58 ft.		
120														



Washington State  
Department of Transportation

## LOG OF TEST BORING

Job No. XL-3493

SR 163

Elevation -11.0 ft

Start Card S-42659

Project SR 160 Vashon Trestle Preservation

HOLE No. H-04-11

Sheet 1 of 5

Site Address Vic of 103rd Ave. + Vashon Hwy. S.W.

Driller Shepherd, Robert Lic# 2710

Inspector Harvey, Thomas #2599

Start January 10, 2011 Completion January 11, 2011 Well ID# \_\_\_\_\_ Equipment CME-55 (9C1-3) - AH

Station \_\_\_\_\_ Offset \_\_\_\_\_ Hole Dia 6 (inches) Method Mud Rotary

Northing 190416.28 Easting 1237521.68 Collected by Region Survey Crew Datum State Plane North

County 17-King Subsection NE1/4 of SE1/4 Section 6 Range 3EWM Township 23N

Depth (ft)	Elevation	Profile	Field SPT (N)				Blows/6"	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			20	40	60	80							
-15.0							1 1 2 (3)	D-1			Silty SAND, very loose, Gray, wet, homogenous, HCl not tested, sm. Fragments of Shells. Length Recovered:0.4 ft. Length Retained:0.4 ft.		
5							5 8 13 (21)	D-2			Silty SAND, medium dense, Gray, moist, homogenous, HCl not tested, sm. Fragments of Shells Trace Silt. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-20.0							8 10 14 (24)	D-3	GS MC		SM, MC=22% Silty SAND, medium dense, Gray, moist, homogenous, HCl not tested, sm. Fragments of Shells Trace Silt. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
10							9 10 10 (20)	D-4	GS MC		SM, MC=22% Silty SAND, medium dense, Gray, moist, homogenous, HCl not tested, sm. Fragments of Shells Trace Silt. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-25.0													
15													
-30.0													
20													



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -11.0 ft

HOLE No. H-04-11

Sheet 2 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile	Blows/6"				Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			◆ Field SPT (N)	✚ Moisture Content	▨ RQD	20 40 60 80						
-35	-35		◆	✚		4 5 10 (15)	D-5	MC AL		MC=30%, PI=7 SILT, medium dense, Gray, moist, homogenous, HCl not tested, Sm. Gravel Layer at 20ft. Silt Starts at 21ft. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-25	-25					11 18 26 (44)	D-6			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-40	-40		◆			12 19 30 (49)	D-7			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-30	-30					14 18 27 (45)	D-8			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-45	-45		◆			12 17 27 (44)	D-9			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-55	-55											
45												



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No XL-3493

SR 163

Elevation -11.0 ft

HOLE No. H-04-11

Sheet 3 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile	Soil Test Data				Sample Type	Sample No. (Tube No.)	Lab	Tests	Description of Material	Groundwater	Instrument
			◆ Field SPT (N)	✚ Moisture Content	▨ RQD	Blows/6"							
			20 40 60 80										
-60	50						17 23 24 (47)	D-10	MC AL		MC=28%, PI=22 SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-65	55						19 26 42 (68)	D-11			SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-70	60						14 22 31 (53)	D-12			SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-75	65						16 21 27 (48)	D-13			SILT, dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-80	70						16 27 42 (69)	D-14			SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -11.0 ft

HOLE No. H-04-11

Sheet 4 of 5

Project SR 160 Vashon Trestle Preservation

Driller Shepherd, Robert

Lic# 2710

Depth (ft)	Elevation (ft)	Profile	Soil Properties				Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			◆ Field SPT (N)	◆ Moisture Content	▨ RQD	Blows/6" (N) and/or RQD FF						
-85	75		◆ 20	◆ 40	▨ 60	80	17 26 35 (61)	D-15	GS MC AL	ML, MC=24%, PI=7 SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-90	80		◆ 20	◆ 40	▨ 60	80	15 24 36 (60)	D-16		SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-95	85		◆ 20	◆ 40	▨ 60	80	15 24 33 (57)	D-17		SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-100	90		◆ 20	◆ 40	▨ 60	80	17 26 31 (57)	D-18	MC AL	MC=22%, LL=NA, PL=NP SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-105	95		◆ 20	◆ 40	▨ 60	80	18 26 46 (72)	D-19		SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		



Washington State  
Department of Transportation

## LOG OF TEST BORING

Start Card S-42659

Job No. XL-3493

SR 163

Elevation -11.0 ft

HOLE No. H-04-11

Sheet 5 of 5

Driller Shepherd, Robert

Lic# 2710

Project SR 160 Vashon Trestle Preservation

Depth (ft)	Elevation	Profile	◆ Field SPT (N) + Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			◆							
				17 26 31 (57)	D-20			SILT, very dense, Gray, moist, homogenous, HCl not tested. Length Recovered:1.5 ft. Length Retained:1.5 ft.		
-110										
100										
-115								The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Division and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
105										
-120								End of test hole boring at 98.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
110										
-125								Bail/Recharge test: Hole Diameter: 6 Depth of boring during bail test: 98.5' Depth of casing during bail test: 92' Bailed bore hole water level to 12' Recharge after 30 minutes :12'		
115										
-130								Deck elevation is 16.54 ft as provided by region survey crew. Mudline is located 27.5 ft below the deck of the ferry trestle. Mudline elevation is calculated at -10.96 ft.		
120										

## **Appendix C – Historic Boring Logs**

- H-10-90
- H-11-90
- H-12-94
- H-13-94

## LOG OF TEST BORING

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. \_\_\_\_\_ S.R. \_\_\_\_\_ SECTION Washington State Ferries Job No. XL-0444  
 Hole No. H-10 Sub Section Vashon Island Ferry Terminal Cont. Sec. 1783  
 Station 7+37 (see Plans) Offset \_\_\_\_\_ Ground El. -21.5'  
 Type of Boring Mobile 8-61 wire line Casing 45.0' HQ W.T. El. Tide Water  
 Inspector \_\_\_\_\_ Date April 17, 1990 Sheet 1 of 3

DEPTH ft	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	3	↑	1 ↑ STD 1 PEN 2 ↓ 1	SP/SM, M.C. = 30.6% Very loose, gray/black, wet, gravelly, silty, fine to coarse SAND with shells and a 1/8" silt (muck) beddings. Retained 0.8'.
5	30	↑	13 ↑ STD 14 PEN 16 ↓ 2	SM, M.C. = 19.2% Dense, greenish gray moist, gravelly, very silty, fine SAND with traces of small wood fragments and shells (no bedding detected). Retained 1.0'.
10	64	↓	18 ↑ STD 24 PEN 40 ↓ 3	Very dense, gray, moist, gravelly, fine to medium sandy SILT with shells (probably push a larger piece of gravel with sampler). Retained 0.05'.
15	95/10"	↑	14 ↑ STD 45 PEN 50/ ↓ 4 4"	ML, M.C. = 24.4% Very dense, gray, moist, gravelly, fine to medium sandy SILT (no bedding detected). Retained 1.1'.
20				

Hole No. H-10 Sub Section Vashon Island Ferry Terminal Sheet 2 of

DEPTH 20	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	96/9"		19 ↑ STD 46 ↓ PEN	Very dense, gray, moist, gravelly, fine to medium sandy
			50/ ↓ 3" 5	SILT (no bedding detected). Retained 1.3'.
25	50/6"		21 ↑ STD 50 ↓ PEN	Very dense, gray, moist, gravelly, fine to medium sandy
			6	SILT (no bedding detected). Retained 1.0'.
30	50/5"		24 ↑ STD 50/ ↓ PEN	Very dense, gray, moist, gravelly, fine to medium sandy
			5" 7	SILT (no bedding detected). Retained 1.0'.
35	50/6"		20 ↑ STD 50 ↓ PEN	ML, M.C. = 25.5% Very dense, gray, moist, gravelly, fine to medium sandy
			8	SILT with shells. (no bedding detected) Retained 1.0'.
40	95/9"		25 ↑ STD 45 ↓ PEN	Very dense, gray, moist, gravelly, fine to medium sandy
			50/ ↓ 3" 9	SILT with shells. (no bedding detected) Retained 0.9'.
45				



## LOG OF TEST BORING

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. \_\_\_\_\_ S.R. \_\_\_\_\_ SECTION Washington State Ferries Job No. XL-0444  
 Hole No. H-11 Sub Section Vashon Island Ferry Terminal Cont. Sec. 1783  
 Station See Plans Offset \_\_\_\_\_ Ground El. -29.0'  
 Type of Boring Mobile B-61 Wireline Casing HQ W.T. El. Tide Water  
 Inspector \_\_\_\_\_ Date April 18, 1990 Sheet 1 of 2

DEPTH 0	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	20	↑	12 ↑ STD 12 ↓ PEN	SM, M.C. = 20.5% Medium dense, gray, moist, gravelly, silty, fine to coarse
			8 ↓ 1	SAND with shell and clear glass fragments. Retained 1.5'.
5		↓		
	70	↑	13 ↑ STD 25 ↓ PEN	ML, M.C. = 25.5% Very dense, gray, moist gravelly, fine to medium sandy SILT
			45 ↓ 2	with shells. (no bedding detected) Retained 1.1'.
10		↓		
	50/6"	↑	22 ↑ STD 50 ↓ PEN	Very dense, gray, moist, gravelly, fine to medium sandy SILT
			3	with shells. (no bedding detected) Retained 1.0'.
15		↓		
	50/6"	↑	23 ↑ STD 50 ↓ PEN	Very dense, gray, moist, gravelly, fine to medium sandy SILT
			4	with shells. (no bedding detected) Retained 1.0'.
20		↓		

Hole No. H-11 Sub Section Vashon Island Ferry Terminal Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
20	50/4"		28 ↑ STD 50/ ↓ PEN 4" 5	Very dense, gray, moist, gravelly, fine to medium sandy SILT with shells. (no bedding detected) Retained 0.8'.
25	50/3"		24 ↑ STD 50/ ↓ PEN 3" 6	ML, M.C. = 23.5% Very dense, gray, moist, fine to medium sandy SILT (no bedding detected). Retained 0.8'.
30	50/6"		22 ↑ STD 50 ↓ PEN 7	Very dense, gray, moist, fine to medium sandy SILT (no bedding detected). Retained 0.7'.
35	50/5"		34 ↑ STD 50/ ↓ PEN 5" 8	Very dense, gray, moist, fine to medium sandy SILT (no bedding detected). Retained 0.8'.
40	50/6"		28 ↑ STD 50 ↓ PEN 9	Very dense, gray, moist, fine to medium sandy SILT (no bedding detected). Retained 0.8'.
				End of boring at 41' below ground elevation.
45				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

### **LOG OF TEST BORING**



Washington State  
Department of Transportation

HOLE No. H-12-94

**PROJECT** Vashon Ferry Terminal Main Slip

Job No. OL-1806

Station 8' 10" from CL Apron Hinge

Offset 4' Lt. of Rt. Curb

## Equipment

Casing HW HQ

**Method of Boring      Wet Rotary**

Start Date February 15, 1994

Completion Date February 17, 1994

Sheet 1 of 4

## LOG OF TEST BORING

Washington State  
Department of Transportation

HOLE No. H-12-94

Sheet 2 of 4  
Job No. OL-1806

PROJECT Vashon Ferry Terminal Main Slip

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft				SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material		Groundwater	Instrument
			10	20	30	40								
1		x . . . . . x . . . . .									SILT with some shell fragments. Did not retain sample.			
7		x . . . . . x . . . . .					9 20 26 (46)	D-7			Hard, gray, moist SILT. (ML). Trace of shell fragments. Homogeneous. Retained 1.0 ft.			
25		x . . . . . x . . . . .					10 19 23 (42)	C-8			SILT with sand. Did not retain sample.			
30		x . . . . . x . . . . .						D-9			ML, M.C. = 25% Hard, gray, moist SILT with sand. (ML). Homogeneous. Retained 1.0 ft.			
35		x . . . . . x . . . . .					12 17 31 (48)	C-10			SILT with sand. No sample taken.			
40		x . . . . . x . . . . .						D-11			Hard, gray, moist SILT with sand. (ML). Homogeneous. Retained 1.0 ft.			
45		x . . . . . x . . . . .						C-12			SILT with sand and a trace of shell fragments. Retained 3.0 ft.			
11		x . . . . . x . . . . .						D-13			ML, M.C. = 28% Hard, gray, moist SILT. (ML). Homogeneous. Retained 1.0 ft.			
12		x . . . . . x . . . . .						C-14			SILT with sand and a trace of shell fragments. Retained 3.0 ft.			
13		x . . . . . x . . . . .					10 20 32 (52)	D-15			Hard, gray, moist SILT with sand. (ML). Homogeneous. Retained 1.0 ft.			
45		x . . . . . x . . . . .						C-16						

## LOG OF TEST BORING



**Washington State  
Department of Transportation**

HOLE No. H-12-94

Sheet 3 of 4  
Job No. OL-1806

**PROJECT** Vashon Ferry Terminal Main Slip

### LOG OF TEST BORING



Washington State  
Department of Transportation

HOLE No. H-12-94

PROJECT Vashon Ferry Terminal Main Slip

Sheet 4 of 4  
Job No. OL-1806

## LOG OF TEST BORING

Washington State  
Department of Transportation

HOLE No. H-13-94

PROJECT Vashon Ferry Terminal Main Slip

Job No. OL-1806

S.R.

Station 21.5' from CL of Bridge Shoe

Offset 4' Rt. of Lt. Curb

C.S. 1783

Equipment

Casing HW HQ

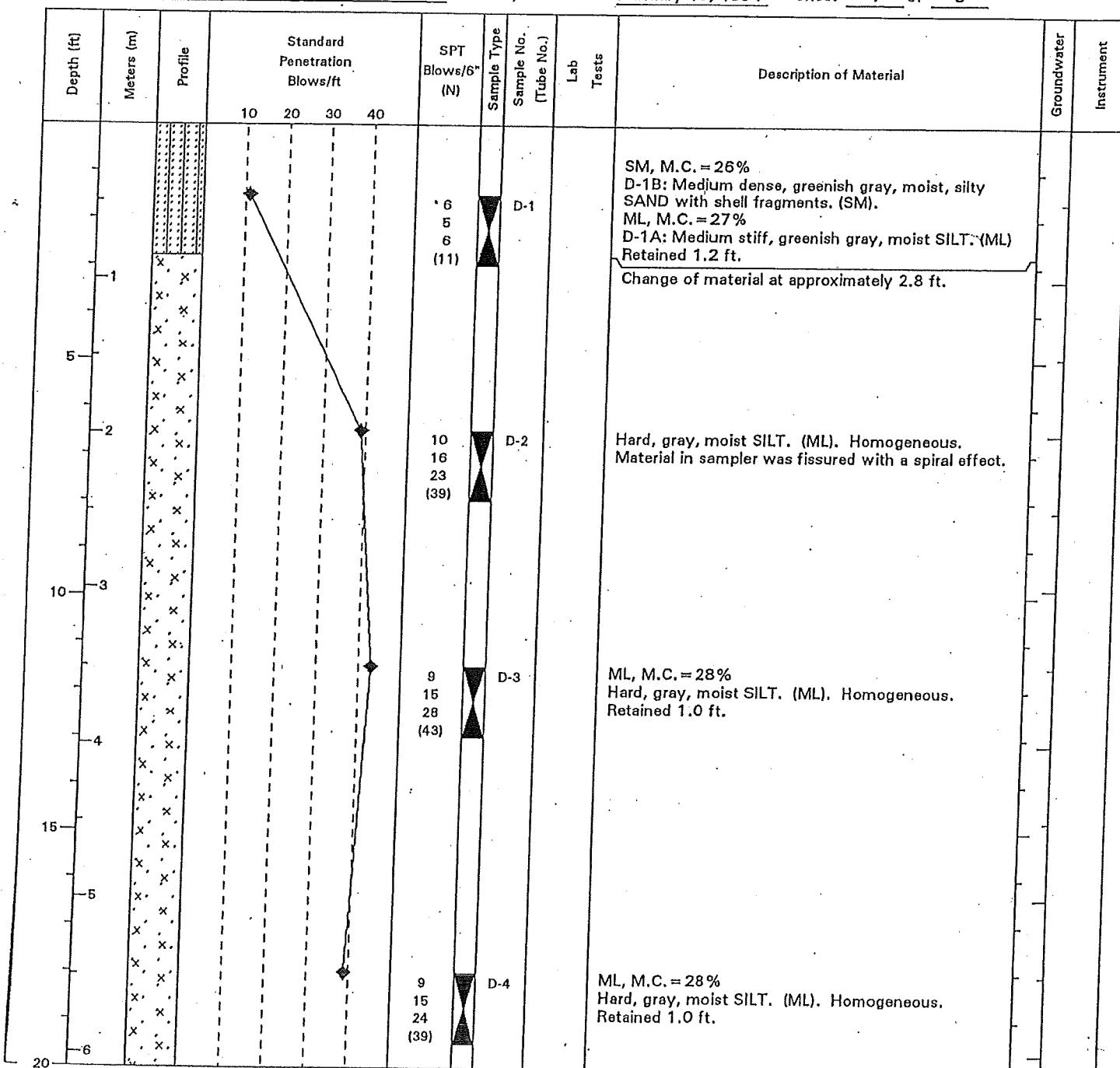
Ground El -30.5 (-9.30 m)

Method of Boring Wet Rotary

Start Date February 18, 1994

Completion Date February 18, 1994

Sheet 1 of 3



### **LOG OF TEST BORING**



Washington State  
Department of Transportation

HOLE No. H-13-94

Sheet 2 of 3  
Job No. OL-1806

**PROJECT** Vashon Ferry Terminal Main Slip

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Description of Material		Groundwater	Instrument
							10	20	30	40
7				10 18 41 (54)	D-5		Hard, gray, moist SILT. (ML). Homogeneous. Retained 1.0 ft.			
25				12 19 21 (40)	D-6		ML, M.C. = 26%			
30				11 18 22 (40)	D-7		Hard, gray, moist SILT. (ML). Homogeneous. Retained 1.3 ft.			
35				17 25 32 (57)	D-8		Very dense, gray, moist SILT. (ML). Homogeneous. Retained 1.0 ft.			
40				7 27 50/5"	D-9		Hard, gray, moist SILT. (ML). Homogeneous. Retained 1.0 ft.			
45							Very hard, gray, moist SILT (ML) with sand laminae in last 6 inches of sample. Retained 1.0 ft.			

### LOG OF TEST BORING



**Washington State  
Department of Transportation**

HOLE No. H-13-94

PROJECT Vashon Ferry Terminal Main Slip

Sheet 3 of 3  
Job No. OL-1806

## **Appendix D – Laboratory Test Results**

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION - MATERIALS LABORATORY  
PO Box 47365, Olympia WA 98504-7365 / 1655 S. 2nd Ave., Tumwater WA 98512  
Chemistry Section

TEST OF MISCELLANEOUS CHEMICAL MATERIALS

Date Logged In: 02/18/2011

SR: 160

Section: VASHON TRESTLE PRESERVATION DESIGN

Contract No: XL3493  
Lab. No: MC-07234  
Transmittal No: 109A72  
Lab ID No: 0000109A72  
Bid Item No:

Material: SOIL FOR LOI TEST  
Source: PIT H-01-11 12' TO 13.5'  
Lot No: STOCKPILE F-9433  
Sample No:

TEST

RESULT

ORGANIC CONTENT BY LOI, % 1.18

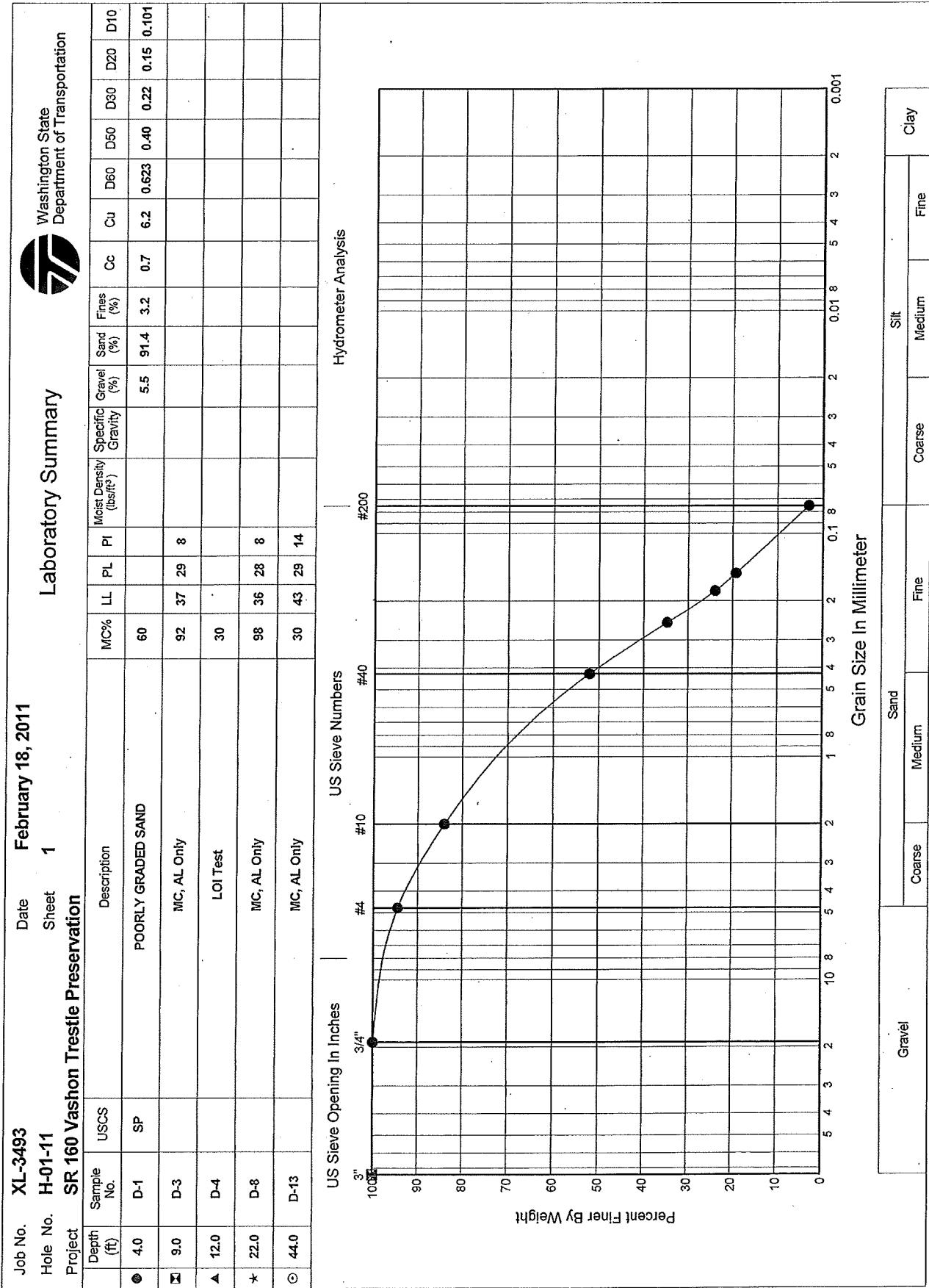
OSC Laboratory

Mat. File X  
General File X  
Region  
Construction 4 X  
Project Engineer:  
PETE PALMERSON X(2)

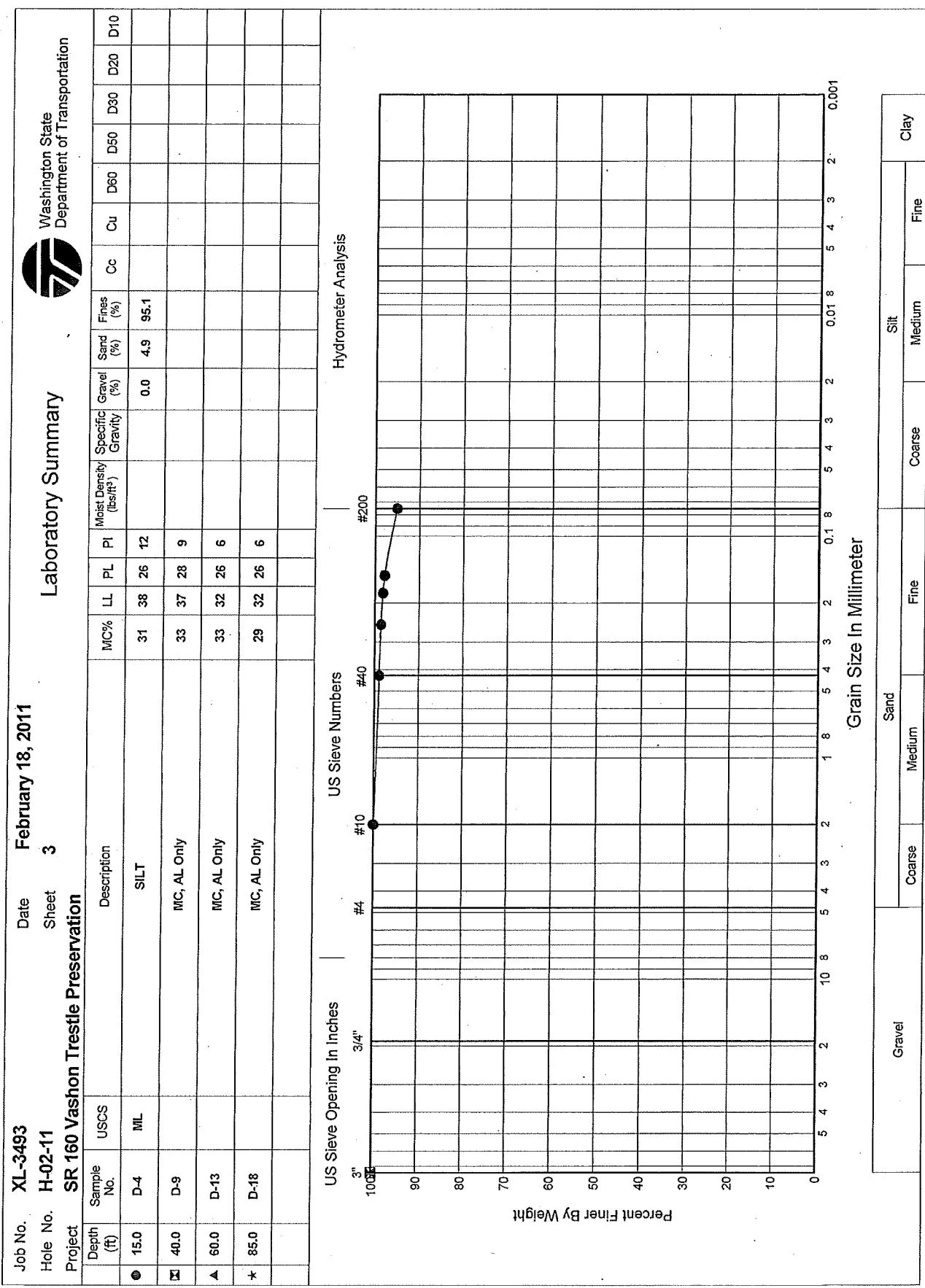
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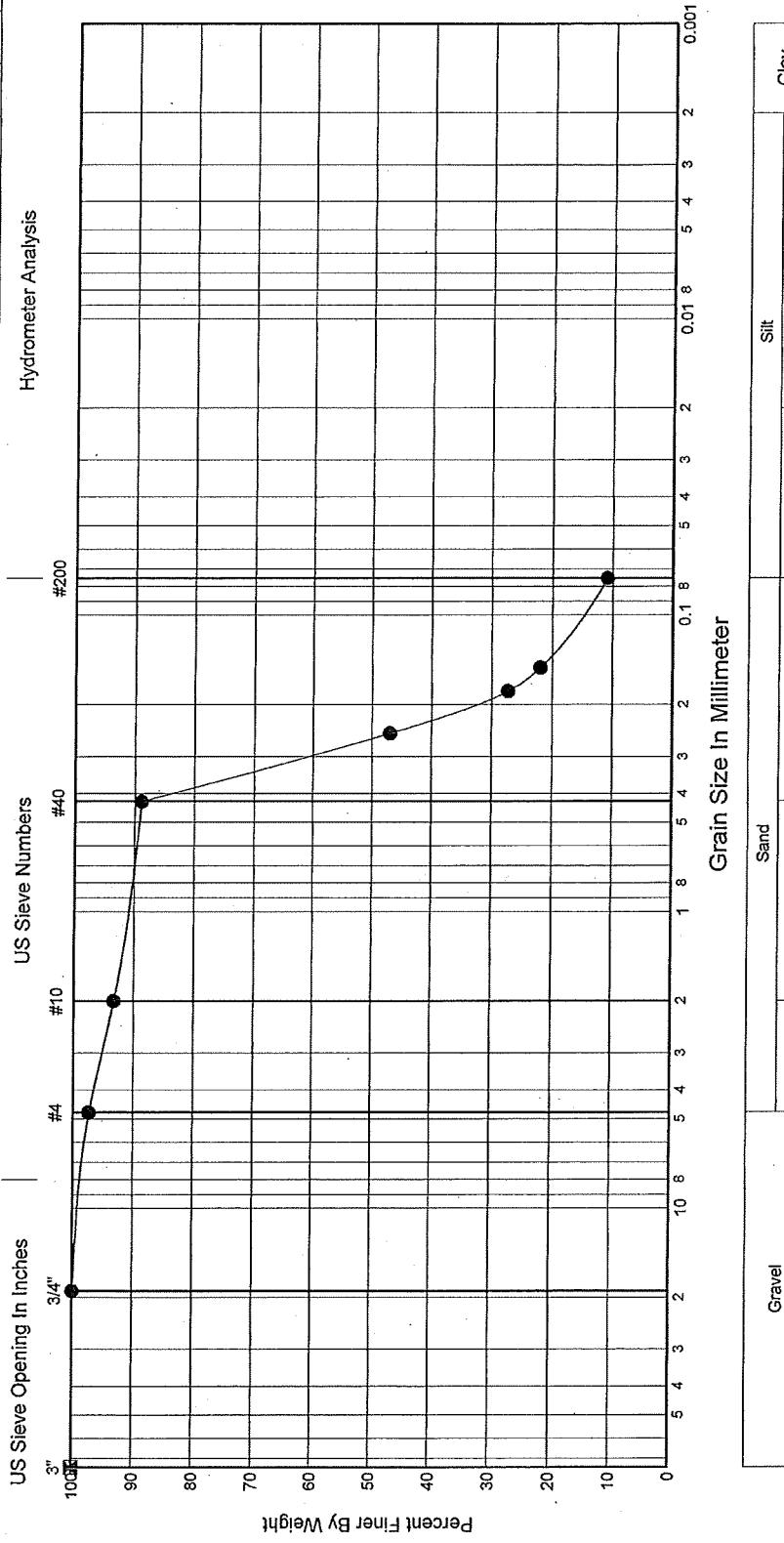
0340 T2L0 T48J  
T2K9  
T2D1 1

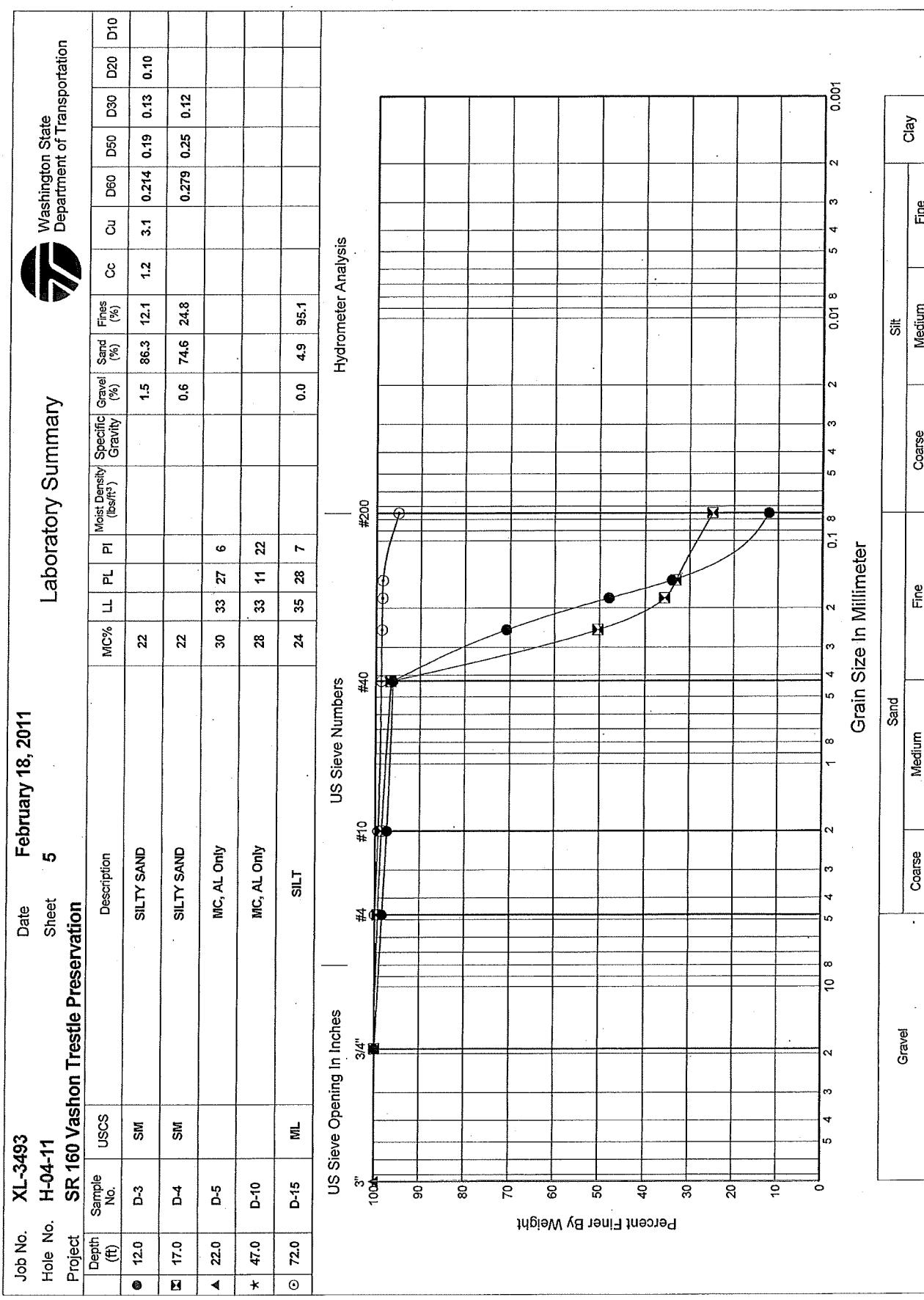
Thomas E. Baker, P.E.  
Materials Engineer  
by: Marilyn Olson  
Date 02/22/2011 Telephone 709-5538









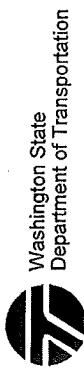


Job No. **XL-3493**  
Hole No. **H-04-11**  
Project **SR 160 Vashon Trestle Preservation**

Date **February 18, 2011**

Sheet **6**

**Laboratory Summary**



Depth (ft)

Sample No.

USCS

Description

MC%, AL Only

PL

PI

Moist Density (lbs/ft³)

Specific Gravity (%)

Gravel (%)

Sand (%)

Fines (%)

Cc

Cu

D60

D30

D20

D10

● 87.0

D-18

22

NA

NP

NA

US Sieve Opening In Inches

3/4"

#4

#10

#40

#200

100%

90

80

70

60

50

40

30

20

10

0

5 4 3 2 10 8 5 4 3 2 1 8 5 4 3 2 0.1 8 5 4 3 2 0.01 8 5 4 3 2 0.001

**Hydrometer Analysis**

Percent Finer By Weight

Gravel	Sand	Silt	Clay
Coarse	Medium	Fine	Fine

## **Appendix E – Historic Laboratory Test Results**

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <u>XL-0444</u> SAMPLE NO.: <u>E-8958-1</u> HOLE NO.: <u>H-10</u> DATE: <u>5-14-90</u> LAB. TECH.: <u>P.A.A.</u>	<b>SOIL FIELD IDENTIFICATION</b>																																																																																																																																								
	TEST	GRAVEL	SAND	SILT	CLAY																																																																																																																																				
	VISUAL	✓	✓	✓																																																																																																																																					
	DRIED CAST																																																																																																																																								
	DILITANCY																																																																																																																																								
<b>SIEVE ANALYSIS</b>	<b>GRAIN SIZE CURVE</b>																																																																																																																																								
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# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <u>XL-0444</u>		SOIL FIELD IDENTIFICATION																				
SAMPLE NO.: <u>E-8958-2</u>	TEST	GRAVEL	SAND	SILT	CLAY																	
HOLE NO.: <u>H-10</u>	VISUAL	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>																		
DATE: <u>5-14-90</u>	DRIED CAST																					
LAB. TECH.: <u>P.A.A.</u>	DILITANCY																					
SIEVE ANALYSIS																						
DRY WT.: <u>51.6g.</u>	GRAIN SIZE CURVE																					
WET WT.: <u>61.5g.</u>	SCREEN SIZE																					
% H <sub>2</sub> O: <u>19.2</u>	3"	2"	1"	½"	#4	#10	#16	#40	#80	#200												
	C. GRAVEL	F. GRAVEL	C. SAND	M. SAND																		
% PASSING	100	80	60	40	20	0																
	60	40	30	20	15	10	8	6	4	3	2.5	2	1.5	1	.8	.6	.4	.3	.25	.15	.1	.08
	GRAIN SIZE — MM																					
LIQUID LIMIT DETERMINATION																						
CLASS.	LIQUID LIMIT										PLASTIC LIMIT											
<u>SM</u>	Can No.																					
	Wet Wt.																					
	Dry Wt.																					
	% H <sub>2</sub> O																	PL=				
	Blows																	PI=				
PLASTICITY CHART																						
PLASTICITY INDEX	60	50	40	30	20	10	0															
	10	20	30	40	50	60	70	80	90	100	LIQUID LIMIT											

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <u>XL-0444</u>		SOIL FIELD IDENTIFICATION				
SAMPLE NO.: <u>E-8958-4</u>		TEST	GRAVEL	SAND	SILT	CLAY
HOLE NO.: <u>H-10</u>		VISUAL	✓	✓	✓	
DATE: <u>5-14-90</u>		DRIED CAST				
LAB. TECH.: <u>P.A.A.</u>		DILITANCY				
		BITE				
		TOUGHNESS				
<b>SIEVE ANALYSIS</b>						
DRY WT.: <u>57.7g.</u>		SCREEN SIZE				
WET WT.: <u>71.8g.</u>		C. GRAVEL	F. GRAVEL	C. SAND	M. SAND	F. SAND
% H <sub>2</sub> O: <u>24.4</u>		%	%	%	%	%
WT. OF SAMPLE: <u>456.9g.</u>		WT.	% PASS			
-1½"	<u>Ø</u>	<u>100.0</u>				
-1"	<u>Ø</u>	<u>100.0</u>				
-¾"	<u>0.3g.</u>	<u>100.0</u>				
-#4	<u>0.5g.</u>	<u>99.9</u>				
-#10	<u>24.1g.</u>	<u>99.8</u>				
-#40	<u>116.4g.</u>	<u>94.6</u>				
-#200	<u>315.6g.</u>	<u>69.1</u>				
<b>SAMPLE DESCRIPTION</b>						
CLASS.	<u>ML GREY, MOIST, FINE GRAVELLY, FINE TO MEDIUM SANDY SILT</u>					
<b>LIQUID LIMIT DETERMINATION</b>						
	LIQUID LIMIT				PLASTIC LIMIT	
Can No.						
Wet Wt.						
Dry Wt.						
% H <sub>2</sub> O					PL=	
Blows					PI=	
<b>PLASTICITY CHART</b>						
PLASTICITY INDEX	10	20	30	40	50	60
Liquid Limit	10	20	30	40	50	60

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <i>XL-0444</i>		SOIL FIELD IDENTIFICATION									
SAMPLE NO.: <i>E-8958-8</i>		TEST	GRAVEL	SAND	SILT	CLAY					
HOLE NO.: <i>H-10</i>		VISUAL	✓	✓	✓						
DATE: <i>5-14-90</i>		DRIED CAST									
LAB. TECH.: <i>P.A.A.</i>		DILITANCY									
		BITE									
		TOUGHNESS									
SIEVE ANALYSIS											
DRY WT.: <i>51.0g.</i>		GRAIN SIZE CURVE									
WET WT.: <i>64.0g.</i>		SCREEN SIZE									
% H <sub>2</sub> O: <i>25.5</i>		C. GRAVEL	F. GRAVEL	C. SAND	M. SAND	F. SAND					
WT. OF SAMPLE: <i>490.0g.</i>		3"	2"	1"	#4	#10	#16	#40	#80	#200	
<i>-1½"</i> <i>-1"</i> <i>-¾"</i> <i>-#4</i> <i>-#10</i> <i>-#40</i> <i>-#200</i>	WT.	% PASS									
	Ø	100.0									
	Ø	100.0									
	0.3g.	100.0									
	0.5g.	99.9									
	18.0g.	99.8									
	110.0g.	96.2									
	361.2g.	73.7									
SAMPLE DESCRIPTION											
CLASS.	<i>ML GREY, MOIST, FINE</i>										
<i>GRAVELLY, FINE TO MEDIUM SANDY SILT WITH SHELL FRAGMENTS</i>											
LIQUID LIMIT DETERMINATION											
	LIQUID LIMIT				PLASTIC LIMIT						
Can No.											
Wet Wt.											
Dry Wt.											
% H <sub>2</sub> O					PL=						
Blows					PI=						
PLASTICITY CHART											
PLASTICITY INDEX	10	20	30	40	50	60	70	80	90	100	
LIMIT	10	20	30	40	50	60	70	80	90	100	

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <u>XL-0444</u>		SOIL FIELD IDENTIFICATION											
SAMPLE NO.: <u>E-8958-1</u>		TEST	GRAVEL	SAND	SILT	CLAY							
HOLE NO.: <u>H-10</u>		VISUAL	✓	✓	✓								
DATE: <u>5-14-90</u>		DRIED CAST											
LAB. TECH.: <u>P.A.A.</u>		DILITANCY											
		BITE											
		TOUGHNESS											
<b>SIEVE ANALYSIS</b>													
DRY WT.: <u>70.5g.</u>		GRAIN SIZE CURVE											
WET WT.: <u>92.1g.</u>		SCREEN SIZE											
% H <sub>2</sub> O: <u>30.6</u>		C. GRAVEL	F. GRAVEL	C. SAND	M. SAND	F. SAND							
WT. OF SAMPLE: <u>225.7g.</u>		8"	2"	1"	#4	#10	#16	#40	#80	#200			
		60	40	30	20	15	10	8	6	4	3		
		% PASSING											
-1½"	Ø	100.0											
-1"	Ø	100.0											
-¾"	<u>0.7g.</u>	100.0											
-#4	<u>9.1g.</u>	99.7											
-#10	<u>60.3g.</u>	95.7											
-#40	<u>141.0g.</u>	68.9											
-#200	<u>14.6g.</u>	6.5											
<b>Liquid Limit Determination</b>													
		LIQUID LIMIT				PLASTIC LIMIT							
CLASS.	SP-SM	Can No.											
GREY, WET,		Wet Wt.											
FINE GRAVELLY,		Dry Wt.											
COARSE TO FINE SAND		% H <sub>2</sub> O				PL=							
WITH SHELL FRAGMENTS		Blows				PI=							
<b>PLASTICITY CHART</b>													
		PLASTICITY INDEX	0	10	20	30	40	50	60	70	80	90	100
		LIQUID LIMIT	10	20	30	40	50	60	70	80	90	100	

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <u>XL-0444</u>		SOIL FIELD IDENTIFICATION																						
SAMPLE NO.: <u>E-8958-2</u>		TEST	GRAVEL	SAND	SILT	CLAY																		
HOLE NO.: <u>H-10</u>		VISUAL	✓	✓	✓																			
DATE: <u>5-14-90</u>		DRIED CAST																						
LAB. TECH.: <u>P.A.A.</u>		DILITANCY																						
		BITE																						
		TOUGHNESS																						
<b>SIEVE ANALYSIS</b>																								
DRY WT.: <u>51.6g.</u>		GRAIN SIZE CURVE																						
WET WT.: <u>61.5g.</u>		SCREEN SIZE																						
% H <sub>2</sub> O: <u>19.2</u>		3"	2"	1"	¾"	½"	#4	#10	#16	#40	#60	#200												
% PASSING -1½" -1" -¾" -#4 -#10 -#40 -#200	WT.	% PASS	C. GRAVEL	F. GRAVEL	C. SAND	M. SAND	F. SAND																	
	Ø	100.0	1	1	1	1	1	1	1	1	1	1												
	Ø	100.0	1	1	1	1	1	1	1	1	1	1												
	0.7g.	100.0	1	1	1	1	1	1	1	1	1	1												
	1.3g.	99.8	1	1	1	1	1	1	1	1	1	1												
	5.0g.	99.4	1	1	1	1	1	1	1	1	1	1												
	252.1g.	98.0	1	1	1	1	1	1	1	1	1	1												
	94.3g.	26.7	1	1	1	1	1	1	1	1	1	1												
<b>Liquid Limit Determination</b>																								
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	LIQUID LIMIT	PLASTIC LIMIT																						
Can No.																								
Wet Wt.																								
Dry Wt.																								
% H <sub>2</sub> O		PL=																						
Blows		PI=																						
<b>PLASTICITY CHART</b>																								

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <i>XL-0444</i>		SOIL FIELD IDENTIFICATION					
SAMPLE NO.: <i>E-8958-4</i>		TEST	GRAVEL	SAND	SILT	CLAY	
HOLE NO.: <i>H-10</i>		VISUAL	✓	✓	✓		
DATE: <i>5-14-90</i>		DRIED CAST					
LAB. TECH.: <i>P.A.A.</i>		DILITANCY					
		BITE					
		TOUGHNESS					
<b>SIEVE ANALYSIS</b>							
DRY WT.: <i>57.7g.</i>		GRAIN SIZE CURVE					
WET WT.: <i>71.8g.</i>		SCREEN SIZE					
% H <sub>2</sub> O: <i>24.4</i>							
WT. OF SAMPLE: <i>456.9g.</i>							
-1½" -1" -¾" -#4 -#10 -#40 -#200	WT.	% PASS					
	Ø	100.0					
	Ø	100.0					
	0.3g.	100.0					
	0.5g.	99.9					
	24.1g.	99.8					
	116.4g.	94.6					
	315.6g.	69.1					
	<b>Liquid Limit Determination</b>						
CLASS. <i>ML</i>	LIQUID LIMIT			PLASTIC LIMIT			
Can No.							
Wet Wt.							
Dry Wt.							
% H <sub>2</sub> O					PL=		
Blows					PI=		
<b>PLASTICITY CHART</b>							
PLASTICITY INDEX	60	50	40	30	20	10	0
LIQUID LIMIT	100	90	80	70	60	50	40

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: XL-0444		SOIL FIELD IDENTIFICATION																					
SAMPLE NO.: E-8958-8		TEST	GRAVEL	SAND	SILT	CLAY																	
HOLE NO.: H-10		VISUAL	✓	✓	✓																		
DATE: 5-14-90		DRIED CAST																					
LAB. TECH.: P.A.A.		DILITANCY																					
		BITE																					
		TOUGHNESS																					
<b>SIEVE ANALYSIS</b>																							
DRY WT.: 51.0g.		GRAIN SIZE CURVE																					
WET WT.: 64.0g.		SCREEN SIZE																					
% H <sub>2</sub> O: 25.5		C. GRAVEL	F. GRAVEL	C. SAND	M. SAND	F. SAND																	
WT. OF SAMPLE: 490.0g.		60	40	30	20	15	10	8	6	4	3	2	1.5	1.0	.8	.6	.4	.3	.2	.15	.1	.05	
-1½"	Ø	100.0																					
-1"	Ø	100.0																					
-¾"	0.3g.	100.0																					
-#4	0.5g.	99.9																					
-#10	18.0g.	99.8																					
-#40	110.0g.	96.2																					
-#200	361.2g.	73.7																					
<b>SAMPLE DESCRIPTION</b>																							
CLASS.	ML GREY, MOIST, FINE GRAVELLY, FINE TO MEDIUM SANDY SILT WITH SHELL FRAGMENTS																						
<b>LIQUID LIMIT DETERMINATION</b>																							
	LIQUID LIMIT				PLASTIC LIMIT																		
Can No.					PL=																		
Wet Wt.																							
Dry Wt.																							
% H <sub>2</sub> O					PL=																		
Blows					PI=																		
<b>PLASTICITY CHART</b>																							
PLASTICITY INDEX	60	50	40	30	20	10	0																
Liquid Limit	10	20	30	40	50	60	70	80	90	100													
Hatched area indicates liquid limit range.																							

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <b>XL - 0444</b>		SOIL FIELD IDENTIFICATION																																								
SAMPLE NO.: <b>E-8959-1</b>		TEST	GRAVEL	SAND	SILT	CLAY																																				
HOLE NO.: <b>H-11</b>		VISUAL	✓	✓	✓																																					
DATE: <b>5-14-90</b>		DRIED CAST																																								
LAB. TECH.: <b>P.A.A.</b>		DILITANCY																																								
		BITE																																								
		TOUGHNESS																																								
<b>SIEVE ANALYSIS</b>																																										
DRY WT.: <b>51.1g.</b>		GRAIN SIZE CURVE																																								
WET WT.: <b>61.6g.</b>		SCREEN SIZE																																								
% H <sub>2</sub> O: <b>20.5</b>		C. GRAVEL	F. GRAVEL	C. SAND	M. SAND	F. SAND																																				
WT. OF SAMPLE: <b>545.4g.</b>		3"	2"	1"	#4	#10	#16	#40	#80	#200																																
-1½"	WT.	% PASS	100	80	60	40	20	0																																		
	Ø	100.0	100	80	60	40	20	0																																		
	-1"	Ø	100.0	100	80	60	40	20	0																																	
	-¾"	<b>39.9g.</b>	<b>100.0</b>	100	80	60	40	20	0																																	
	-#4	<b>3.9g.</b>	<b>92.7</b>	100	80	60	40	20	0																																	
	-#10	<b>15.0g.</b>	<b>92.0</b>	100	80	60	40	20	0																																	
	-#40	<b>378.4g.</b>	<b>89.2</b>	100	80	60	40	20	0																																	
	-#200	<b>108.2g.</b>	<b>19.8</b>	100	80	60	40	20	0																																	
<b>SAMPLE DESCRIPTION</b>																																										
CLASS.	LIQUID LIMIT DETERMINATION																																									
<b>SM</b>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th colspan="3">LIQUID LIMIT</th> <th colspan="2">PLASTIC LIMIT</th> </tr> </thead> <tbody> <tr> <td>Can No.</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Wet Wt.</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Dry Wt.</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>% H<sub>2</sub>O</td> <td></td> <td></td> <td></td> <td>PL=</td> <td></td> </tr> <tr> <td>Blows</td> <td></td> <td></td> <td></td> <td>PI=</td> <td></td> </tr> </tbody> </table>							LIQUID LIMIT			PLASTIC LIMIT		Can No.						Wet Wt.						Dry Wt.						% H <sub>2</sub> O				PL=		Blows				PI=	
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Blows				PI=																																						
<b>GRANULARITY</b> <b>GREY, MOIST,</b> <b>GRAVELLY, SILTY,</b> <b>FINE TO COARSE</b> <b>SAND WITH SHELL</b> <b>FRAGMENTS AND</b> <b>CLEAR GLASS</b> <b>FRAGMENTS</b>																																										
<b>PLASTICITY CHART</b> <p>PLASTICITY INDEX</p> <p>LIMIT</p>																																										

# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <u>XL-0444</u>		SOIL FIELD IDENTIFICATION																		
SAMPLE NO.: <u>E-8959-2</u>		TEST	GRAVEL	SAND	SILT	CLAY														
HOLE NO.: <u>H-11</u>		VISUAL	✓	✓	✓															
DATE: <u>5-14-90</u>		DRIED CAST																		
LAB. TECH.: <u>P.A. A.</u>		DILITANCY																		
		BITE																		
		TOUGHNESS																		
<b>SIEVE ANALYSIS</b>																				
DRY WT.: <u>60.4g.</u>		GRAIN SIZE CURVE																		
WET WT.: <u>75.8g.</u>		SCREEN SIZE																		
% H <sub>2</sub> O: <u>25.5</u>		C. GRAVEL	F. GRAVEL	C. SAND	M. SAND	F. SAND														
WT. OF SAMPLE: <u>429.6g.</u>		3"	2"	1"	¾"	½"	#4	#10	#16	#40	#80	#200								
% PASSING -1½" -1" -¾" -#4 -#10 -#40 -#200	WT.	100					80					60								
	Ø	100.0					80					60								
	Ø	100.0					80					60								
	1.8g.	100.0					80					60								
	1.7g.	99.6					80					60								
	27.5g.	99.2					80					60								
	111.3g.	92.8					80					60								
	287.3g.	66.9					80					60								
	<b>Liquid Limit Determination</b>							40					20							
	LIQUID LIMIT							40					20							
CLASS.	Can No.											PL=								
ML	Wet Wt.											PI=								
SAMPLE DESCRIPTION							Dry Wt.													
GREY, MOIST, FINE GRAVELLY, FINE TO MEDIUM SANDY SILT WITH SHELL FRAGMENTS							% H <sub>2</sub> O													
PLASTICITY CHART							Blows													
PLASTICITY INDEX							LIQUID LIMIT													
0 10 20 30 40 50 60							0 10 20 30 40 50 60 70 80 90 100													

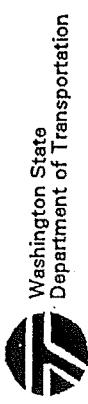
# SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: <u>XL-0444</u>		SOIL FIELD IDENTIFICATION									
SAMPLE NO.: <u>E-8959-6</u>		TEST	GRAVEL	SAND	SILT	CLAY					
HOLE NO.: <u>H-11</u>		VISUAL		✓	✓						
DATE: <u>5-14-90</u>		DRIED CAST									
LAB. TECH.: <u>P.A.A.</u>		DILITANCY									
		BITE									
		TOUGHNESS									
GRAIN SIZE CURVE											
SCREEN SIZE											
<small>% PASSING</small> <small>WT.</small>	3"	2"	1"	3/4"	1/2"	#4	#10	#16	#40	#80	#200
	C. GRAVEL	F. GRAVEL	C. SAND	M. SAND	F. SAND						
	1	1	1	1	1						
	1	1	1	1	1						
	1	1	1	1	1						
	1	1	1	1	1						
	1	1	1	1	1						
	1	1	1	1	1						
	1	1	1	1	1						
	1	1	1	1	1						
GRAIN SIZE — MM											
60 40 30 20 15 10 8 6 4 3 2 1.5 1.0 .8 .6 .4 .3 .2 .15 .1 .08											
LIQUID LIMIT DETERMINATION											
		LIQUID LIMIT				PLASTIC LIMIT					
Can No.											
Wet Wt.											
Dry Wt.											
% H <sub>2</sub> O					PL=						
Blows					PI=						
PLASTICITY CHART											
60 50 40 30 20 10 0											
PLASTICITY INDEX											
10 20 30 40 50 60 70 80 90 100											
LIQUID LIMIT											
(A diagonal line starts at (10, 5) and ends at (100, 100). A hatched area is bounded by the x-axis, the y-axis, and the line.)											

Job No. OL-1806  
 Hole No. H-12-94  
 Project Vashon Ferry Terminal Main Slip

Date March 9, 1994  
 Sheet 1 of 1

### Laboratory Summary



Washington State  
 Department of Transportation

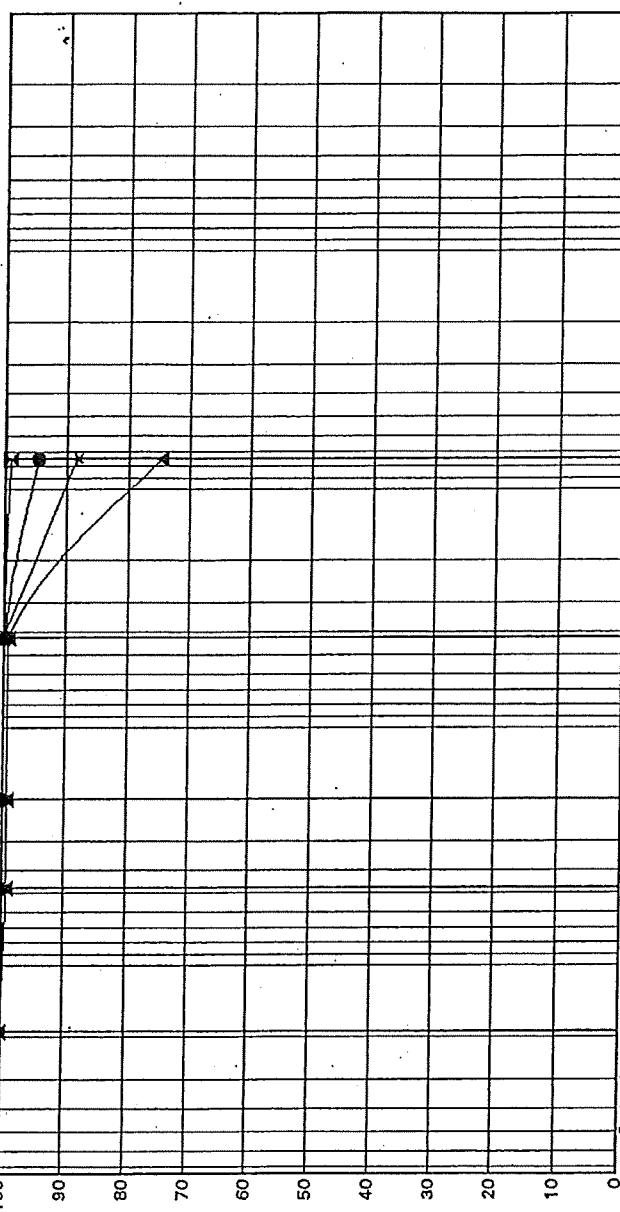
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	1.0	0.30	D-1	ML	GRAY	SILT	27	NP	NP	NP
☒	11.0	3.35	D-3	ML	GRAY	SILT	28	NP	NP	NP
▲	27.5	8.38	D-9	ML	GRAY	SILT with SAND	25	NP	NP	NP
*	37.5	11.43	D-13	ML	DK. GRAY	SILT	28	NP	NP	NP

### GRADATION FRACTIONS

%Gravel	%Sand	%Fines	Cu	Cc
●	0.0	5.4	94.6	
☒	0.0	1.0	99.0	
▲	0.9	24.6	74.5	
*	0.0	11.5	88.5	

### US Sieve Opening In Inches

100% #3 3/4" 1/2" #40 #10 #40 #200

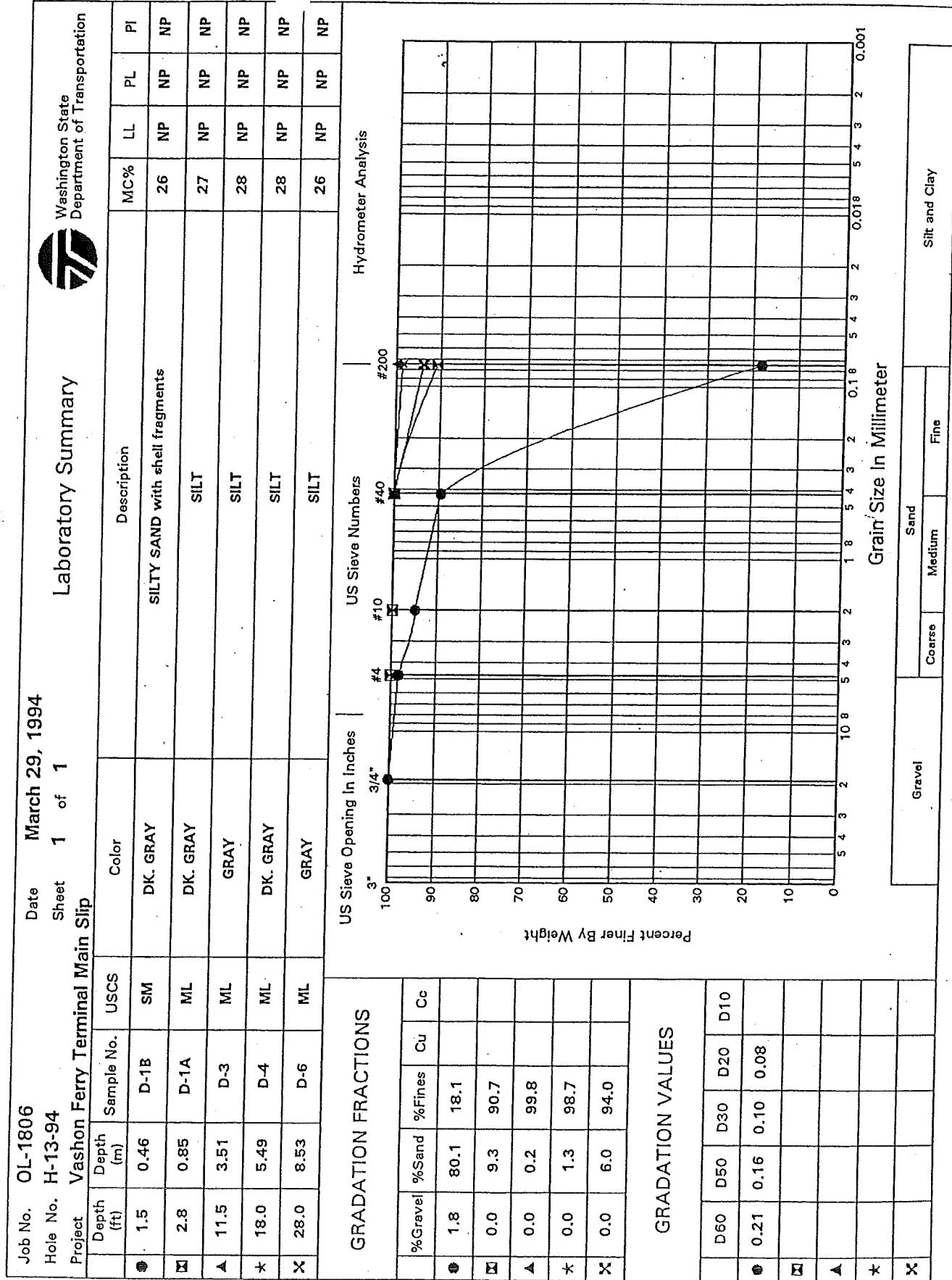


Percent Finer By Weight

### GRADATION VALUES

D60	D50	D30	D20	D10
●				
☒				
▲				
*				

Grain Size In Millimeter	Sand			Silt and Clay		
	Coarse	Medium	Fine	Coarse	Medium	Fine



## **Appendix F – Design Parameters**

- Table 1 – L-pile Parameters
- Plot 1 – 18” Pre-cast Pre-stressed Concrete H-01-11, H-02-11, H-03-11
- Plot 2 – 18” Pre-cast Pre-stressed Concrete H-04-11
- Plot 3 – 24” Pre-cast Pre-stressed Concrete H-01-11, H-02-11, H-03-11
- Plot 4 – 24” Pre-cast Pre-stressed Concrete H-04-11
- Plot 5 – 30” Steel Pile (Open Toe) H-01-11, H-02-11, H-03-11
- Plot 6 – 30” Steel Pile (Open Toe) H-04-11
- Plot 7 – Nominal Bearing Resistance

## P-y CURVE SOIL DATA

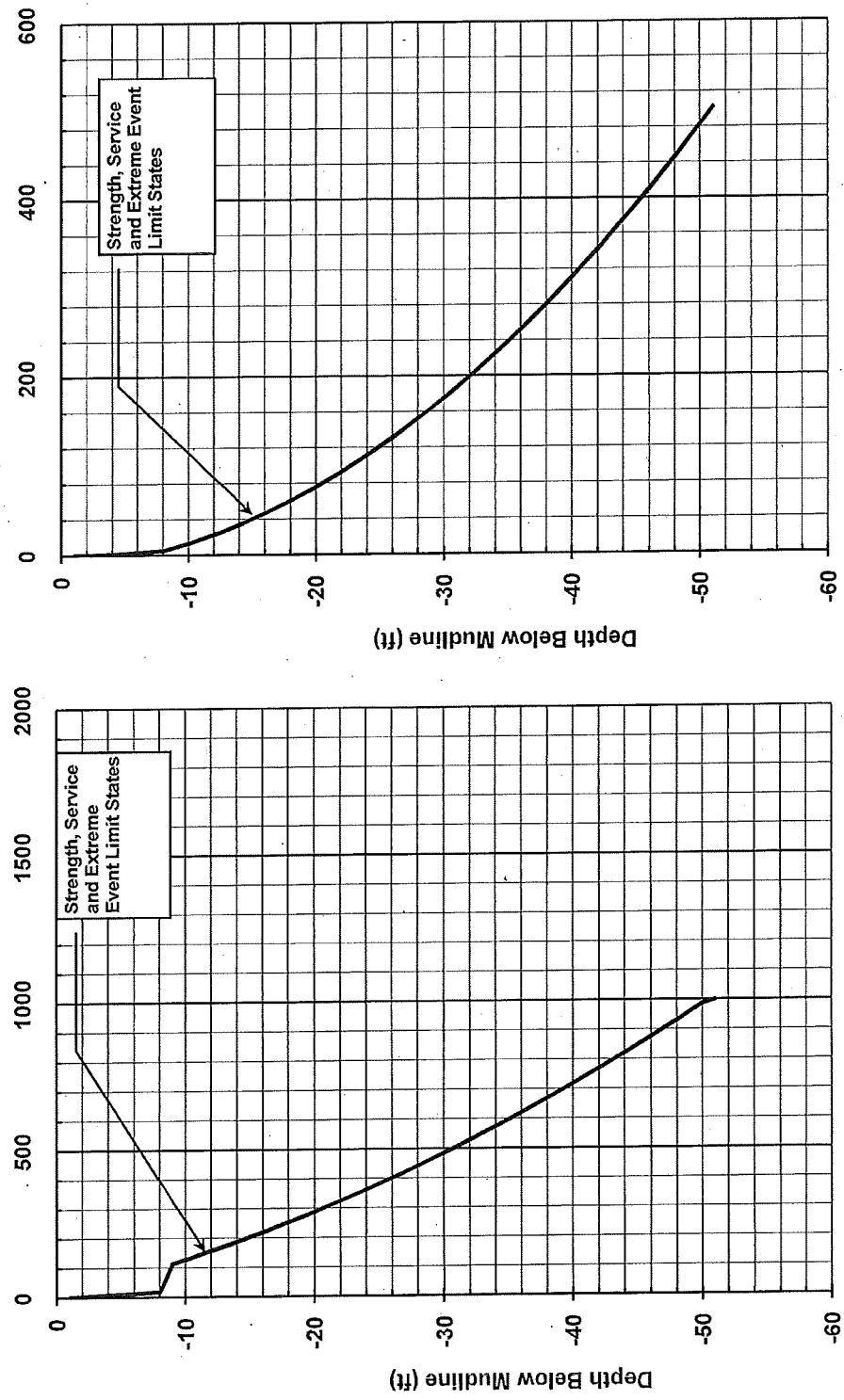
Soil Layer	Depth Below Mudline		Soil Type	Soil Profile Type (KSOIL)	STATIC AND SEISMIC ANALYSIS					
	Starting Depth	Ending Depth			Effective Unit Weight of Soil	Saturated Undrained Strength, $S_u$	Axial Strain $\epsilon_{50}$	Friction Angle $\phi$	Modulus of Subgrade Reaction	
	ft	ft	pcf	pcf	pcf	pcf	(%)	(deg)	(pcf)	(pcf)
1	0	-11	SAND	4	56	0.032			30	30
2	-11	-100	SAND	4	46	0.027			40	140

Table 1

XL-3493 Vashon Trestle Preservation  
Pile Diameter: 18-inch  
Pile Type: Precast Prestressed Concrete

### Nominal Axial Pile Resistance vs. Depth

Soil at borings H-01-11, H-02-11, H-03-11



Nominal Axial Pile Resistance (kips)

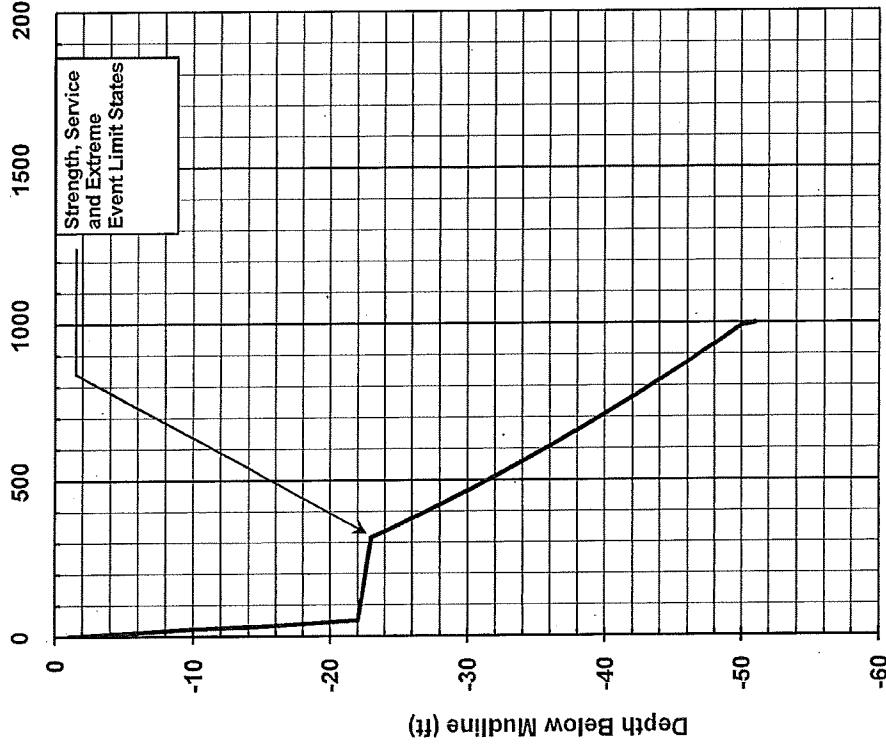
Nominal Uplift Resistance (kips)

Plot 1

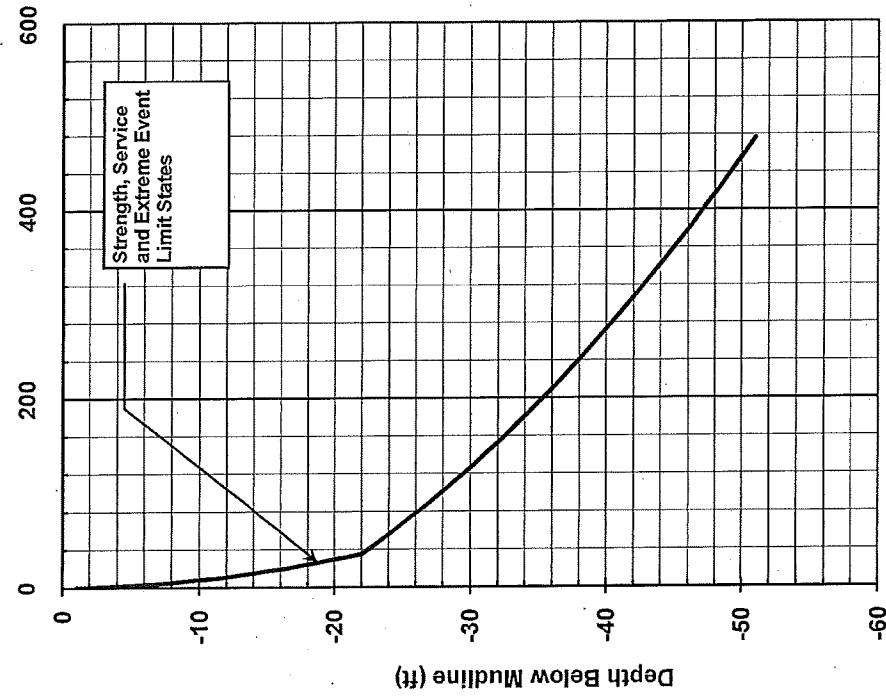
XL-3493 Vashon Trestle Preservation  
Pile Diameter: 18-inch  
Pile Type: Precast Prestressed Concrete

Soil at boring H-04-11

### Nominal Axial Pile Resistance vs. Depth



Nominal Axial Pile Resistance (kips)



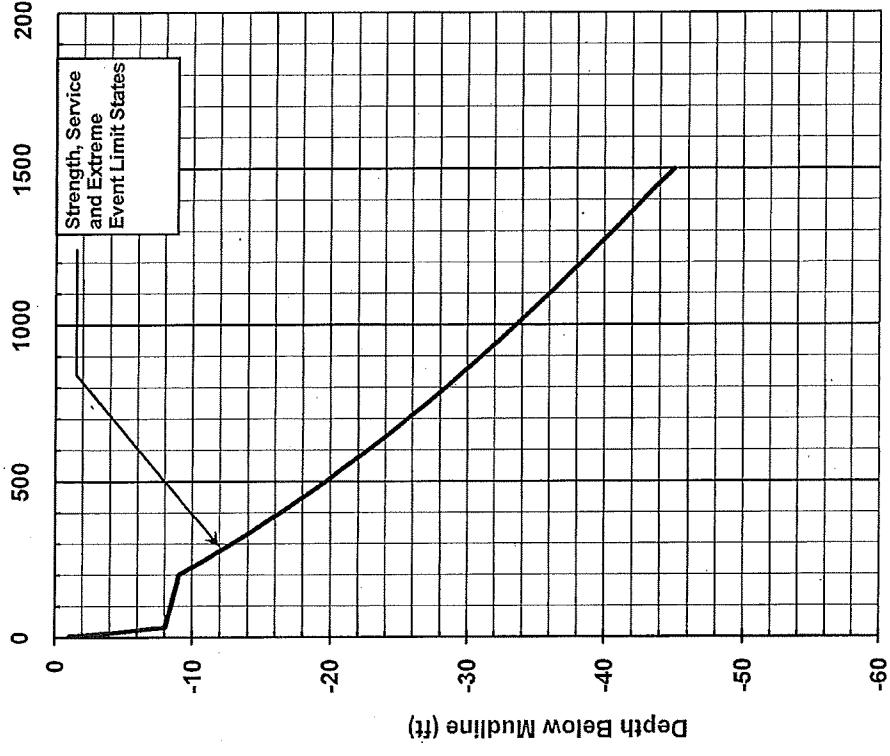
Nominal Uplift Resistance (kips)

### Plot 2

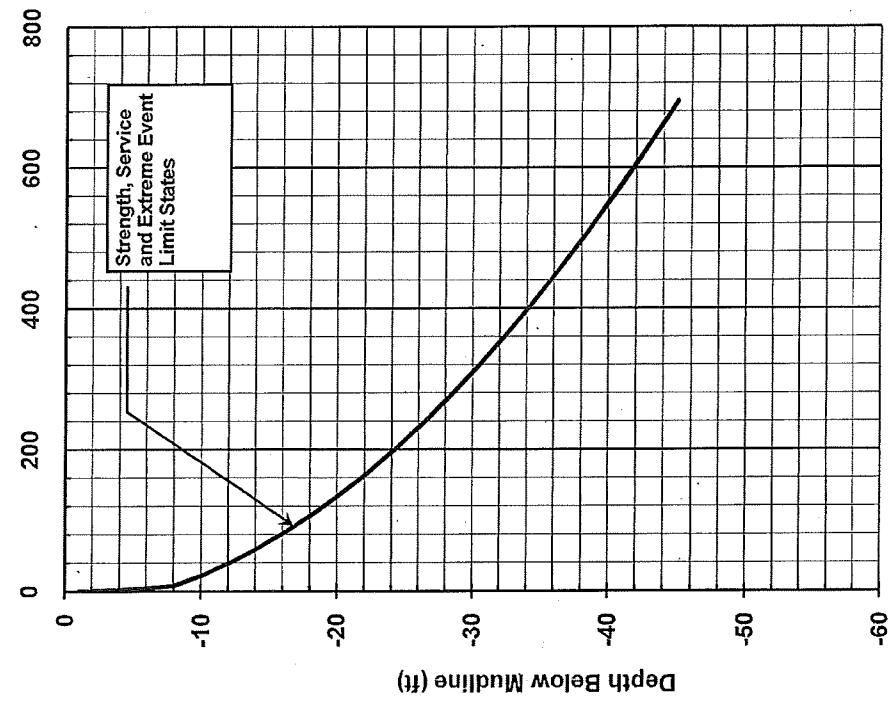
XL-3493 Vashon Trestle Preservation  
Pile Diameter: 24-inch  
Pile Type: Precast Prestressed Concrete

Soil at borings H-01-11, H-02-11, H-03-11

### Nominal Axial Pile Resistance vs. Depth



Nominal Axial Pile Resistance (kips)



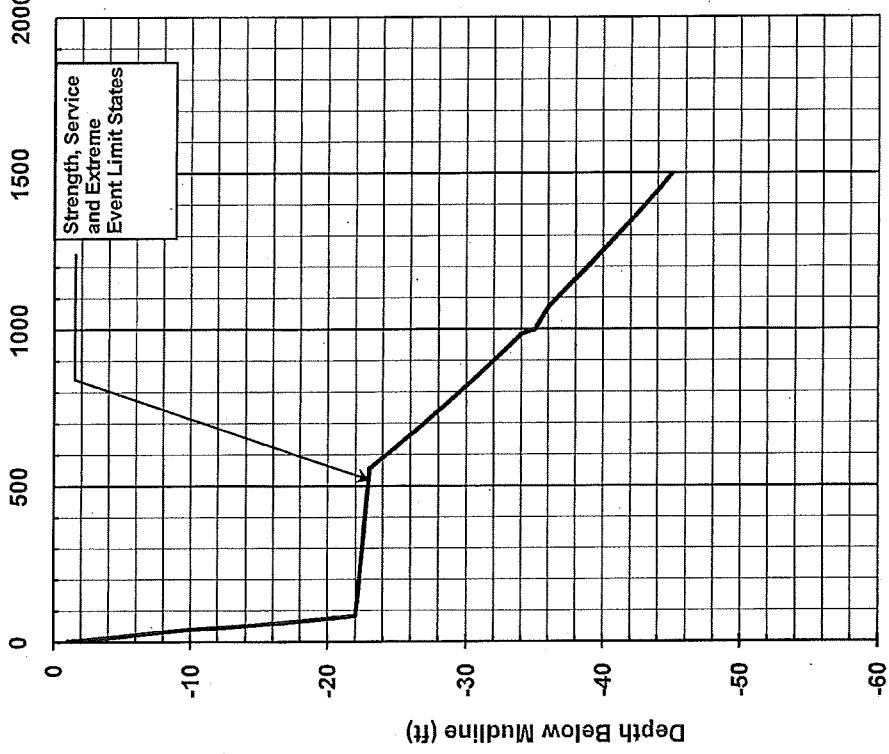
Nominal Uplift Resistance (kips)

**Plot 3**

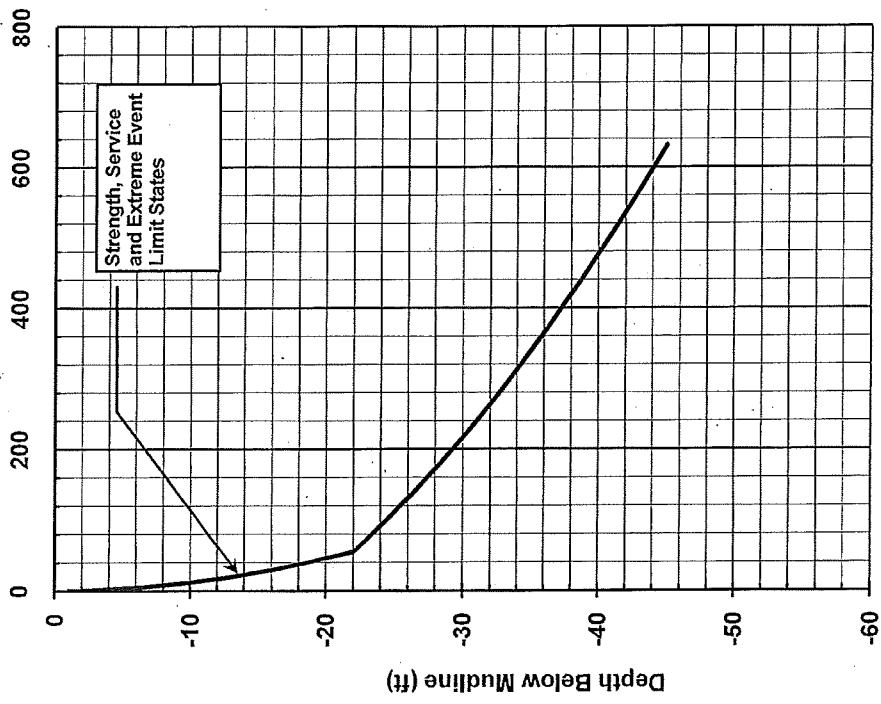
XL-3493 Vashon Trestle Preservation  
Pile Diameter: 24-inch  
Pile Type: Precast Prestressed Concrete

Soil at boring H-04-11

### Nominal Axial Pile Resistance vs. Depth



Nominal Axial Pile Resistance (kips)



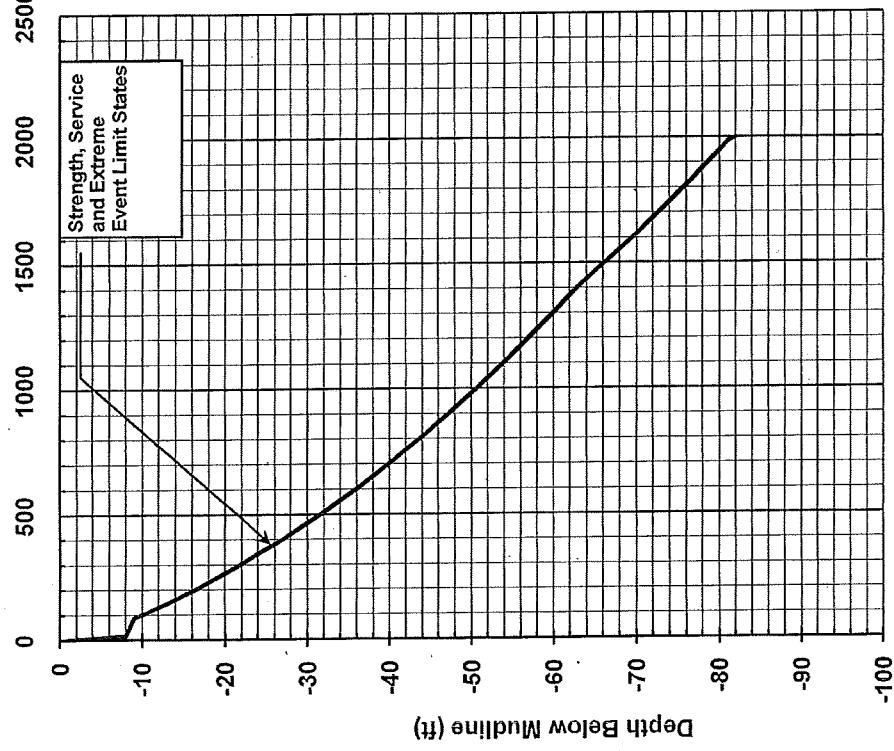
Nominal Uplift Resistance (kips)

**Plot 4**

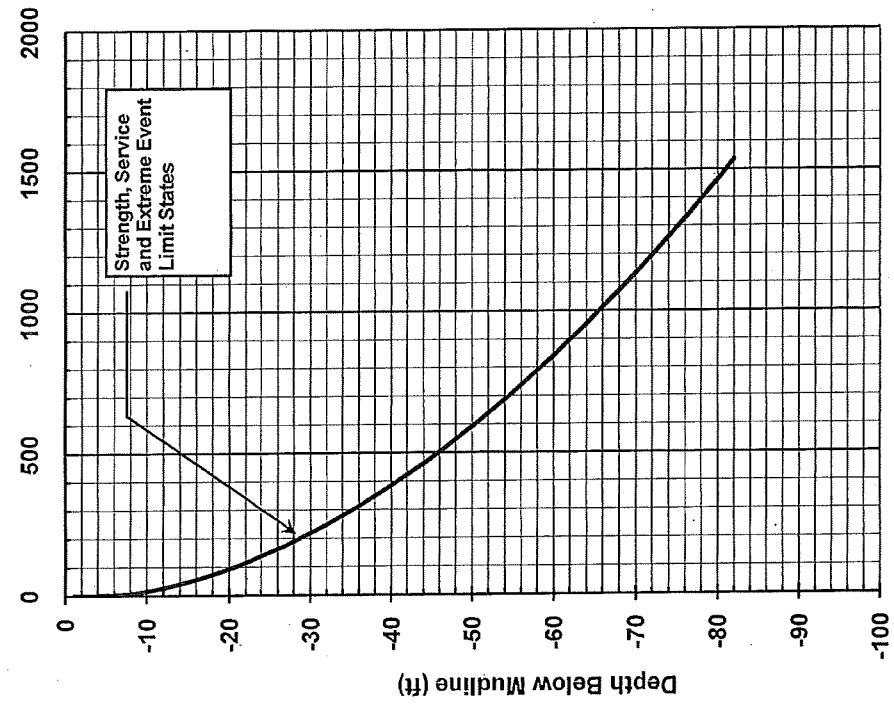
XL-3493 Vashon Trestle Preservation  
Pile Diameter: 30-inch  
Pile Type: Steel Pile (Open Toe)

Soil at borings H-01-11, H-02-11, H-03-11

### Nominal Axial Pile Resistance vs. Depth



Nominal Axial Pile Resistance (kips)



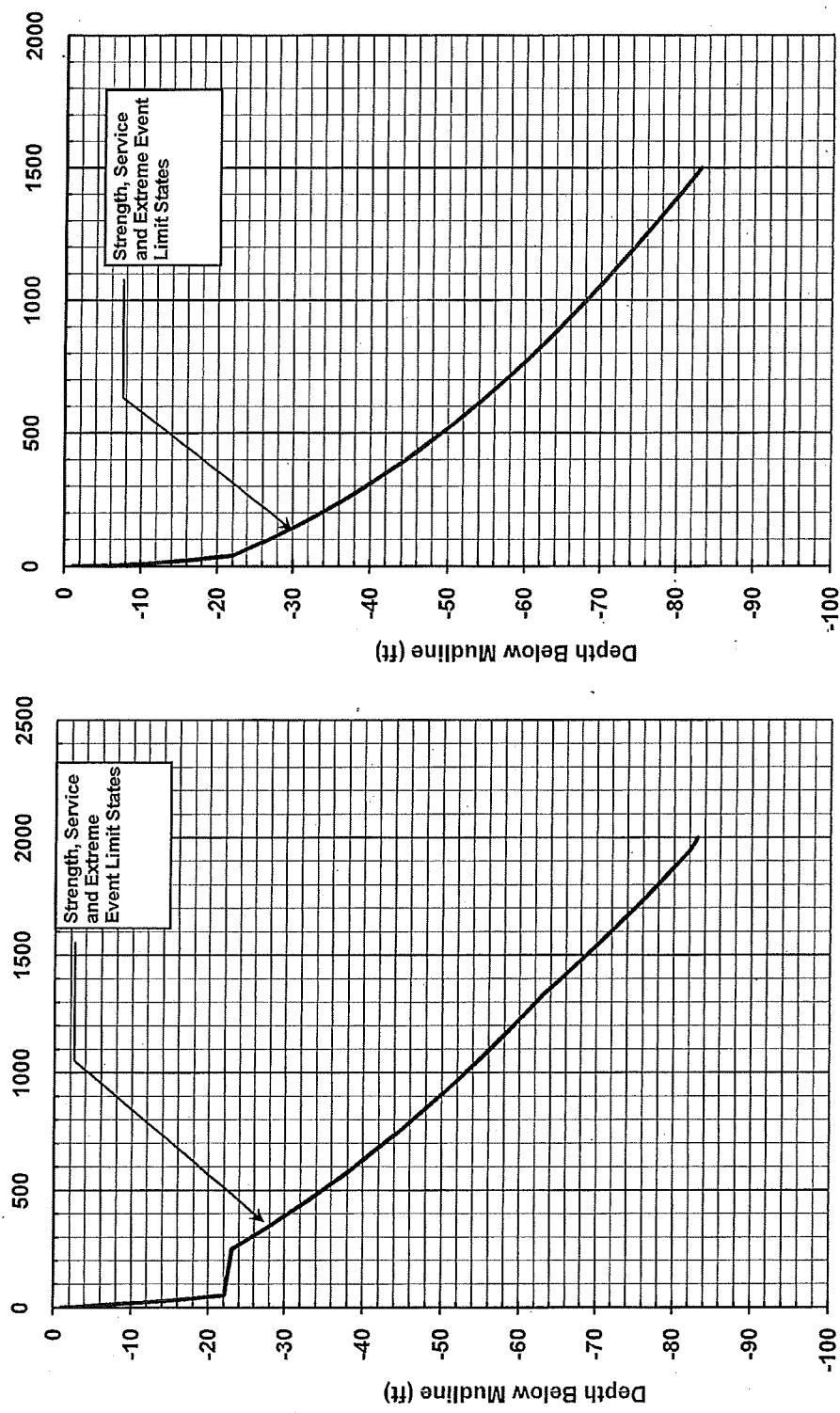
Nominal Uplift Resistance (kips)

**Plot 5**

XL-3493 Vashon Trestle Preservation  
Pile Diameter: 30-inch  
Pile Type: Steel Pile (Open Toe)

Soil at boring H-04-11

### Nominal Axial Pile Resistance vs. Depth



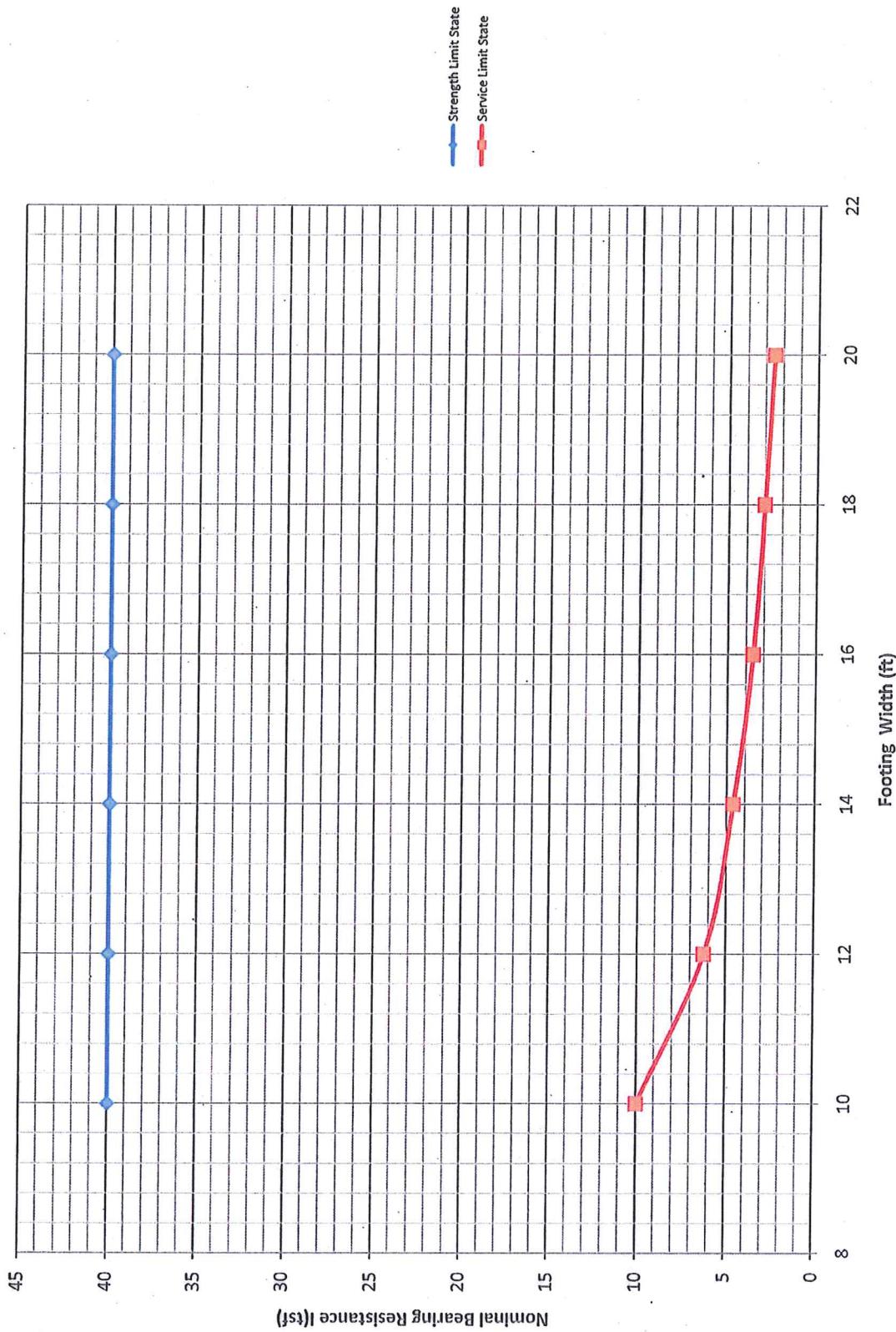
Nominal Axial Pile Resistance (kips)

Nominal Uplift Resistance (kips)

### Plot 6

## Plot 7

Vashon Ferry Terminal Timber Replacement



Nominal Bearing Resistance based on footing 2 feet thick with a minimum of 2 feet of cover, with the bottom of the footing at least 7 feet below the surface.  
Service Limit State based on 1-inch of settlement